

Evaluation of STEM Cymru 2

Final report

Presented to **Engineering Education Scheme
in Wales (EESW)**

by **Arad Research**

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Arad Research
8 Columbus Walk
Brigantine Place
Cardiff / Caerdydd CF10 4SD
029 2044 0552
www.arad.wales

ymchwil
arad
research

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Glossary

CAD	Computer Aided Design
CCT	Cross Cutting Themes
CNC	Computer Numerical Control
CPD	Continuing Professional Development
EESW	Engineering Education Scheme in Wales
ESF	European Social Fund
FLL	First Lego League
FSM	Free School Meals
HEI	Higher Education Institution
ITE	Institute of Engineering and Technology
i2E	Introduction to Engineering
LNF	Literacy and Numeracy Framework
MAT	More Able and Talented
NSA	National Science Academy
SLT	Senior Leadership Team
SRO	Senior Responsible Officer
STEM	Science, Technology, Engineering and Mathematics
ULN	Unique Learning Number
WBQ	Welsh Baccalaureate Qualification
WEFO	Welsh European Funding Office
WW&V	West Wales and the Valleys

Executive summary

STEM CYMRU 2 OVERVIEW

STEM Cymru 2 is a three-year European Social Fund funded project aimed at 11-19-year olds in the West Wales and the Valleys region to encourage participation in engineering activities and improve STEM skills. Engineering Education Scheme in Wales (EESW) organised and delivered the activities under five different strands.

Strand	Activity
EESW Sixth Form Project	Students work on a project with employers
Headstart Cymru	A sixth form university-based residential course
Girls into STEM	Years 8 and 9 girls visit industry and universities
F1 in Schools Challenge	Students design and compete in this national project.
Introduction to Engineering (i2E)	Years 8 to 10 experience practical engineering-based activities (includes the Lego League Challenge).

The EESW activities provide “a real world working experience for students. The administration and communication are excellent, and we are very happy to be involved.” (Schoolteacher)

OPERATION AND DELIVERY

EESW are delivering quality engagement opportunities and successfully building on previous activities and collaboration. The organisation has built professional relationships with a wide range of schools, individual teachers, Further

Education colleges, universities and employers based on trust.



To date almost 5,000 participants have engaged in STEM Cymru 2 activities; with all targets for male and female participation and completion of training exceeded by 30 per cent. It is expected that the overall targets for the full term of the project will be achieved.

COLLABORATION BETWEEN EMPLOYERS, SCHOOLS AND COLLEGES

“Sustaining a core group of employers has been key for the success of the programme. It’s a two-way conversation, it’s about balancing capabilities and the needs of employers and schools.”
(EESW representative)

Participating schools, Higher Education Institutions and employers all developed strong partnerships, which have contributed to the delivery of successful outcomes including skills development, awareness of career possibilities, raised aspirations for students and enhanced knowledge for some teachers. Even though collaboration has been positive, currently there is a lack of synergy and co-operation between EESW and other STEM engagement / enrichment providers.

“It [EESW project] provides good exposure to HE for these students. It’s helpful for engagement, they see progression possibilities – it’s changing aspirations. It’s good for the university too, we forge links with other schools in the area.”
(University supporting EESW project). ”

EFFECTIVENESS OF THE DIFFERENT STRANDS OF ACTIVITY

Students reported their reasons for wanting to participate in EESW activities:

- The opportunity to visit the world of work;
- Engaging in something that was ‘real’;
- To include the experience on CVs and university applications;
- The challenge of trying to solve problems,
- The opportunity to gain new skills;
- The opportunity to consider STEM careers.

*“I enjoyed working as a group and thinking independently. It’s quite cool, it’s a real-life project. You have a sense of responsibility, you must produce a solution to a problem.”
(Participant)*

Different recruitment approaches were adopted by schools to engage students. Some schools targeted more able students already engaged with STEM subjects. While others offered the opportunity to students who were becoming at risk of being disengaged, and others provided the opportunity to whole year groups.

All participants reported they developed practical and transferable skills as a result of their participation in STEM Cymru 2 activities. Some of the skills developed include:



- Communication
- Teamwork
- Problem solving
- Research skills
- Confidence
- Creativity

STEM Cymru 2 activities raised awareness of STEM for all participants, with an improved understanding of the role of STEM in industry and better awareness of the different career options.

EFFICIENCY OF OUTPUTS AND ACHIEVED RESULTS

Content delivered during STEM Cymru 2 activities supports the school curriculum; with links to the Literacy and Numeracy Framework, opportunities to support A level subjects and elements of the Welsh Baccalaureate Qualification reported.



Lessons delivered to other students have also been enhanced by the STEM Cymru 2 activities; with teachers, who attend site visits and events sharing the experiences in the classroom. Some students also achieved their CREST Award.

The focus on being ‘real’ and ‘practical’ proved a key success factor Students participating in all STEM Cymru 2 activities reported that the ‘real focus’ and practical nature of the experience was very important to them.

The aspirations of other students in schools was possible by increasing the profile of STEM by publicising the STEM Cymru 2 activities and achievements within schools and their communities. Regional awards and competitions provide a platform for students to showcase their work, gain recognition and engage with other STEM activities.

Partnerships developed with employers and they gained access to solutions. There are now closer links between the schools/colleges, universities and employers involved as a result of participation in STEM Cymru 2 activities. Some examples of viable solutions to ‘real problems’ have been proposed to employers by the participating student groups.

“Developing an idea, taking it to product and presenting it to industry experts - this is the skillset required to succeed in our industry. The difference is, these young people get to experience this while they’re in school, most don’t get to do this till their 20s or 30s.” (Employer)

EFFECTIVENESS OF OUTPUTS AND RESULTS IN RELATION TO FEMALE PARTICIPATION

STEM Cymru 2 has successfully challenged female stereotypes.

Some activities are delivered by female engineers and/or supported by females in similar roles. Female students participating in all the strands, reported developments in their confidence to pursue further studies and careers in Engineering and STEM related subjects. Monitoring data recorded by EESW evidences that participation figures for females are being achieved overall.

*“If I were to go into an engineering job now, I would be excited to show – yes I’m a girl and yes I can do it.”
(Female participant)*

EFFECTIVENESS OF ADDRESSING THE CROSS-CUTTING THEMES

STEM Cymru 2 is addressing the cross-cutting themes required through ESF funding.

- Activities supported under the programme are addressing gender stereotypes and breaking down perceived barriers for females within STEM education and careers.
- Activities also contain a strong focus on sustainable development through a focus on alternative energy sources.
- Activities tackle poverty by supporting local employers and universities to create employment and progression opportunities within disadvantaged communities.

VALUE FOR MONEY

The STEM Cymru 2 project offers good value for money in relation to the in-kind support it has gained from employers and HEIs. This efficiency is also gained without compromise to the quality of the project delivery and the outcomes achieved.

RAISING AWARENESS AND INTEREST IN STEM

Participation in STEM Cymru 2 increases enthusiasm for, and awareness of the practical application of STEM subjects, particularly engineering. Students and teachers reported an advantage in gaining a place on a STEM related course at their preferred university. The activities encouraged a few students who previously considered other HEI options to now consider engineering as a university course of their choice to study. Even though a couple of the strands are directed towards those who already study and have an interest in STEM subjects, they do add value in relation to nurturing further enthusiasm in STEM

subjects and improved access to the preferred university courses.

However, recording the number of participating students who go on to study STEM subjects at university has been challenging. Evidence to quantify the impact of the project in this respect is therefore limited.

RECOMMENDATIONS

For EESW

1. EESW need to emphasise to schools the importance of the goodwill of employers and universities in contributing to the success of STEM Cymru 2 activities. At the same time the need for additional support and input from engineers, particularly towards the beginning of the students' engagement could also be reinforced.
2. EESW should ensure examples of completed Sixth Form Projects are made available to participants and their supporting staff at appropriate times during the course of the activity.
3. EESW should work with schools to deliver larger in-school events. This would ensure students of all abilities have the opportunity to participate in STEM Cymru 2 activities, widening access to STEM study opportunities and potential career routes.
4. The real context of the STEM Cymru 2 activities is an important success factor which needs to be maintained in the ongoing delivery of the project.
5. EESW should continue to prioritise the support of Girls into STEM, using female role models who direct, deliver and support sessions as often as possible.
6. EESW should continue to work with employers and training providers to develop progression routes to allow STEM Cymru 2 participants the opportunity to access quality jobs within their locality.
7. EESW should explore opportunities for closer connection and participation progression between the different strands.

8. EESW should market the different strands of STEM Cymru 2 to schools as a package. This would enable senior school staff to understand the connections and opportunities available for different year groups.
9. STEM Cymru 2 activities should continue to be aimed at students who have already chosen or demonstrate an interest to study STEM subjects in the future, as participation in the activities supports and guides their continued study and career progression in STEM aspirations.

For Welsh Government

10. Welsh Government should work with schools to introduce methods of tracking and monitoring the progression of students with regards to attainment in STEM subjects and their progression routes.
11. An audit and mapping exercise of enrichment STEM activities should be undertaken. This would give the education sector clarity regarding opportunities for collaboration and provide an overview of activities across Wales.

1. Introduction

1.1 Introduction and objectives of the evaluation

Arad Research was commissioned by Engineering Education Scheme in Wales (EESW) in August 2016 to evaluate STEM Cymru 2, a three-year European Social Fund (ESF) funded operation aimed at 11-19 year olds in the West Wales and the Valleys (WW&V) region. The original ESF approved grant was £1,654,523; with the original submission for the grant also including £157,625 teacher match funded time.

STEM Cymru 2 builds on the STEM Cymru project (2010-2015) to encourage young people to participate in engineering activities and improve STEM skills. The key operation objectives for STEM Cymru 2 are:

- Increase the number of young people participating in Science, Technology, Engineering and Mathematics (STEM) activities and training with a particular focus on increasing the participation of young women;
- Increase the take up of Science, Technology, Engineering and Maths (STEM) subjects in Further Education and Higher Education / apprenticeships;
- Increase attainment in STEM subjects.

In addition to assessing the progress against targets for the above key operation objectives the evaluation was tasked to assess:

- How efficiently were the outputs and results achieved in relation to the Business Plan and Welsh European Funding Office (WEFO) Targets and was this consistent across target groups?
- How effective were the five different strands of activity in achieving the targets of the operation?
- How effective are the outputs and results achieved in relation to female participation?
- How effective are the cross-cutting themes of Environmental Sustainability and Equal Opportunities in relation to the delivery of the strands?
- How effective is the collaboration between employers, schools and colleges?
- The quality of Operation delivery, including its management and administrative systems;
- Value for money.

1.2 Context to the development of STEM Cymru 2

The *State of Engineering* report highlighted the need to improve STEM education and attract young people into engineering, recommending that more students need to be encouraged to choose STEM subjects and make ‘well-informed choices that maintain the option of a career in engineering and technology’.¹

The STEM professions are important to the success and vitality of a nation and its economy. However, there are skill shortages across the STEM sector with women in the minority in terms of employment rates. UNESCO promotes an overarching priority for gender equality at all levels of education and throughout women’s careers.² The Welsh Government also highlights the importance of diversity and equality.³ The different activity strands delivered by STEM Cymru 2 aim to perform a significant role in the drive to address equality and diversity in the STEM sector and encourage young people to consider careers in STEM.

EESW has delivered schemes to motivate young people in Wales to choose careers in STEM since 1989. Since 2010, the ESF has enabled EESW to develop and extend these activities through the STEM Cymru project in WW&V area.⁴ STEM Cymru 2 delivers activities via five main strands (Table 1). More detailed information about the strands, including the events delivered by EESW, is included in Annex 1.

Table 1: The five activity strands supported by STEM Cymru 2

Strand	Overview
EESW Sixth Form Project	Sixth form and college students work with employers on a practical project (Sept -March). Teams present their projects at Big Bang Events in north and south Wales.
Headstart Cymru	Year 12 students spend two or three residential days at a university engaged in activities to help them consider technology focused careers.
Girls into STEM	Females in years 8 and 9 are encouraged to consider engineering careers via visits to industry and universities, practical activities are also included.
F1 in Schools Challenge	This is an established national project. Students’ computer aided designs are converted into model racing cars. Teams compete against each other in relation to design and car performance in races and presentations at regional finals.
Introduction to Engineering (i2E)	Years 8 to 10 experience practical engineering-based activities, delivered in schools or company/university settings. This strand also includes the Lego League Challenge.

¹ Engineering UK (2017) *The State of Engineering*. p. iv.

² UNESCO (2016) *SAGA (STEM and Gender Advancement) Improved measurement of gender equality in science, technology, engineering and mathematics*.

³ A more equal Wales is one of seven well-being goals in the Welsh Government’s *Well-being of Future Generations (Wales) Act*.

⁴ West Wales and the Valleys region qualify for this European Union funding.

1.3 Methodology

Arad adopted a mixed-methods approach to the evaluation. Firstly, a review of contextual documents (e.g. business plans) was undertaken as well as feedback data and information already gathered from operation participants and stakeholders by EESW. This information was reviewed with a view to gaining a clear understanding of all the operation objectives, targets and progress to date and establishing baseline data against which evaluation data gathered as part of this study could be measured.

Arad worked with EESW to map out a ‘results chain’ for each strand of the project, which identified the links between inputs, activities, outputs and outcomes. This intervention logic framework provided the structure around which the evaluation was planned and delivered, including the design of research tools. A copy of this framework is included in Annex 2, and copies of the interview guides conducted with students, school/college staff, Higher Education Institutions (HEIs) and employers are included in Annex 3.

Arad undertook a detailed fieldwork stage, which involved a range of interviews, school visits and focus groups across the duration of the evaluation. This fieldwork involved interviews with the Senior Responsible Officer (SRO) and other members of the STEM Cymru 2 team as well as contact with WEFO representatives. The focus of the fieldwork involved visiting a sample of schools and colleges, and consultations with participants (students), teachers and senior leadership team (SLT) representatives as well as associated employers and HEIs. Arad also undertook consultations with a range of stakeholders and these are listed in Annex 4 along with the interview guide.

Table 2 provides a breakdown of the visits undertaken for each strand of the STEM Cymru 2 project. Samples were discussed with EESW during the early phases of the evaluation and related to ensuring coverage across the separate strands of the programme as well as geography, participation rates and Welsh language. Having gathered all the evaluation evidence from the fieldwork and desk research stages Arad analysed the findings around the themes and structure of the intervention logic model detailed in Annex 2. The qualitative data gathered was transcribed, coded and analysed. Quantitative and qualitative data gathered through project feedback questionnaires developed by EESW as well as EESW monitoring data were also analysed as part of this stage to provide additional evidence relating to project outcomes and impact.

Table 2: Consultations informing the evaluation

Strand	Activities*	Number of EESW events attended by research team	Breakdown of consultations			
			Participants	School/college staff	Employers	University staff
EESW Sixth Form Project	Launch events (10), workshops (11) and 'Big Bang' events (2)	1 Launch 8 workshops 2 Big Bang events	109	16	16	4
Headstart Cymru	3-day residential courses (4)	2 (a day during each course)	19			
Girls into STEM	Industry visits /IT workshops (50)	5 events / site visits	69	6	2	5
F1 in Schools Challenge	Finals (2)	2 Finals 1 school visit	40	6		
i2E	Workshops (79)	6 class delivery sessions 1 Lego League Challenge event (linked to i2E)	80 (**28)	5 (**1)		
Follow up employer interviews		No events				5
Total		26	317	33	23	9

Note: approximately 30 EESW Sixth Form Project students were interviewed twice during the project; at workshops and the final event. Three employers recorded above are universities.

*Total number of activities and events delivered in brackets.

**Two groups completed a Girls into STEM event and Introduction to Engineering on the same day (28 students and 1 teacher consulted). The event is recorded for both strands above, to avoid counting a student twice the student/staff numbers in brackets are not included in the total figures.

1.4 Report structure

This report presents the final evaluation findings and includes an overview of quantitative data collected by EESW and qualitative data collected by Arad between September 2016 and November 2017, the report contains:

- Information on STEM Cymru 2 and the Welsh context (Sections 1 and 2);
- The operation and delivery of STEM Cymru 2 (Section 2);
- The quality of STEM Cymru 2's collaboration and partnership working (Section 2);

- The effect of STEM Cymru 2 on
 - student participants; (Section 3);
 - schools/ colleges; (Sections 2 and 3);
 - employers; (Section 2);
 - universities. (Section 2);
- Views of STEM stakeholders such as Science Learning contract holders and Welsh Government (Section 2);
- Case studies extracts, shorter illustrations of activity and full case studies exemplify practice (throughout report and Annex 6);
- Further detail on several aspects of the evaluation, such as information about each STEM Cymru 2 strand and interview guides, is included in the annexes.

2. The operation and delivery of STEM Cymru 2

This section presents an analysis of the operation and delivery of STEM Cymru 2 activities and examines the motivation of schools, employers and HEIs to engage with them. The effectiveness of collaboration between employers, HEIs, and schools and colleges is also discussed. Progress against targets for STEM Cymru 2 is included, along with evidence relating to WEFO's cross cutting themes – equal opportunities, tackling poverty and sustainable development.

Key findings

The operation and delivery of STEM Cymru 2:

- EESW are delivering quality engagement opportunities and successfully building on previous activities and collaboration;
- Schools, universities and employers are broadly positive about EESW's management and delivery of the programme and the timing and relevance of activities;
- Operational challenges for EESW include teacher release, budgetary pressures on schools, staff changes and focus on the curriculum delivery and exam results;
- Good quality collaboration activities have been supported and have had positive outcomes in terms of Continuing Professional Development (CPD), development of local progression routes and engagement with STEM;
- Challenges for some schools included time commitments and securing engagement of their senior leadership team;
- There is a lack of a strategic level organisation to broker effective co-operation between STEM engagement /enrichment providers across Wales;
- Progress against participation targets is very good with almost 5,000 participants by September 2017;
- Many elements of STEM Cymru 2 delivery address the Cross-Cutting Themes of sustainable development, equal opportunities and tackling poverty.

2.1 Quality of operation and delivery

2.1.1 Views on EESW support and communication

Developing positive and sustainable relationships with schools, colleges and universities is key to engagement with STEM Cymru 2 activities. Overall, schools were very positive in their assessment of the levels of support and communication provided by EESW as part of the programme. Teaching staff highlighted the quality and timeliness of the information received from EESW to support decisions to participate in the various strands. Schools frequently reported previous positive engagement with STEM Cymru 1 activities as being key to their decision to participate in STEM Cymru 2 activities, suggesting that EESW are delivering quality engagement opportunities and successfully building on previous activities and collaboration.

"EESW are a really professional organisation – they and the project have lived up to its billing. It is providing a real world working experience for students. The administration and communication are excellent, and we are very happy to be involved." (EESW Sixth Form Project schoolteacher)

Participating teachers reported that they were keen for students to receive careers and employability information during the STEM Cymru 2 activities. The research team observed EESW staff providing clear explanations, using real-world examples of jobs and everyday applications of science and technology during each of the activities they delivered. The delivery of each strand of STEM Cymru 2 observed by the project team also included a specific focus on associated career paths and future opportunities in the engineering industry and the wider STEM sector.

Discussions with students and teachers following these sessions outlined that this wider focus on careers was appreciated as part of motivating students and providing them with further information and options for future progression, with one teacher commenting '*it creates real aspirations to progress onto HE, seeing the faculties, the professors and students. Open days aren't real, this type of project is.*'

Representatives from participating HEIs also expressed positive views regarding the management and delivery of STEM Cymru 2. Several universities reported that the role of EESW had been 'helpful' in supporting them to manage and coordinate the programme, particularly in terms of bridging their links and contacts with the schools. This support freed up the time of universities to enable them to focus on developing the activities themselves.

Other university representatives made positive comments regarding the 'time and effort' put in by EESW staff to ensure that the operation delivers on its aims and objectives. Several employers expressed similar positive views, highlighting EESW's ongoing communications through the project as being one of the keys to their successful involvement in the operation.

"It has been a very beneficial relationship with EESW. Their communications are really good, and they keep us up to date. The students and schools are happy and there is constant feedback, which is really encouraging." (Employer)

EESW representatives highlighted the importance of building on the contacts made during the first iteration of STEM Cymru and of sustaining the momentum developed through the first project through regular communication, activities and events. Staffing structures thus reflect the need to engage across the eligible regions of Wales, develop sustainable collaboration opportunities and ensure the quality of management and delivery required. Representatives reported that they have formed professional relationships with a wide range of schools, individual teachers, Further Education (FE) colleges, universities and employers based on trust and that this collaboration formed the basis for their operations and delivery.

"It's a constant process – sustaining old employer contacts while engaging new ones. Sustaining a core group of employers has been key for the success of the programme. It's a two-way conversation, it's about balancing capabilities and the needs of employers and schools."

(EESW representative)

2.1.2 Timing and relevance of activities

For EESW representatives there were operational challenges faced during delivery. These included obtaining permission for teachers to be released from their teaching roles, budgetary pressures on schools to engage with external initiatives with their focus on the curriculum delivery and exam results. Representatives also noted that staff changes can affect the sustainability of the activities delivered and awareness of them within schools. EESW reported that they had responded to these challenges by offering a flexible approach to schools regarding timing and availability of activities and worked with them to ensure relevance to their STEM goals and curriculum delivery.

Several participating schools highlighted the importance of this flexible approach. One school highlighted the flexibility of EESW in offering to bring the activity to their premises as 'it was difficult to arrange to take 30 students out of school.' For example, an F1 in Schools Challenge event was undertaken at a school that could not attend the main F1 in Schools Challenge finals. Examples were also observed of combining an i2E session with a Girls into STEM employer site visit. The i2E session was delivered at the employer site followed by a conducted tour of the engineering plant. This flexible approach not only ensured time efficiency, but also appeared to enhance the overall experience for the participating students, by combining a practical classroom style science and engineering activity within a real engineering environment where the science and technology was being applied.

Many teachers viewed the time needed to enable students to participate in activities to be reasonable. However, others noted that they experienced difficulties obtaining permission from their school's senior management to release students to participate in various activities. Some teachers and lecturers also commented on the high level of time commitment needed to support students and that this had impacted on the overall success of the activities. EESW representatives outlined that they are mindful of time constraint challenges for schools and aim to plan the delivery of STEM Cymru 2 activities around demands placed on the time of students and teachers.

For example, the Sixth Form project is launched as soon as possible in September; workshop sessions at HEIs are organised for before Christmas when the HE students are away, thus ensuring participants have good access to workshop facilities and support from HEI staff; and the end of project events are organised in March to ensure that they do not clash with preparations for summer exams. A few teachers and lecturers nevertheless suggested further moving some of the elements of activities to allow students more time to complete the tasks and maintain enthusiasm e.g. timing of the launch and workshops for Sixth Form activities could be earlier in the project.

As a result, although delivering the requirements of the Sixth Form project within the given timescale can be challenging to participants, EESW consider it difficult to plan how further delivery adjustments could be made while accommodating the other academic commitments of the schools, colleges and students.

A strong majority of participating schools highlighted the relevance and suitability of STEM Cymru 2 activities and reported that these linked to their own aspirations for STEM students and curriculum delivery. For these schools, participating in the operation was an opportunity to deliver additional activities linked to the development of STEM-based skills and career progression. Activities were seen by teachers as either contributing to, and enhancing existing STEM-based activity or, in some cases, acting as a catalyst to promote the subject within schools.

For example, one school had recently introduced Computer Science as an optional GCSE course. They considered the delivery of i2E Microbit sessions delivered to year 8 and 9 students at their school as an excellent way of introducing the subject to students. Computer Science teachers at the school also noted that they found they picked up classroom delivery techniques from the sessions which they could then include in their own Computer Science lesson plans. Another teacher reported that they are building the profile of Design and Technology through STEM Cymru 2 activities and are expecting to develop greater take up at Year 10 as a result.

"There is a big push on STEM subjects in the school so this (i2E) is contributing to that. It can also encourage positive attainment. I link what is learned in the session to the curriculum e.g. energy production, they will remember this session. We try to sustain the momentum too, there are STEM clubs and robotics clubs in school and this is all part of influencing options during year 8." (Teacher)

Several schools reported that publicising their involvement with the EESW Sixth Form Project, during assemblies and school annual award events, supported the process of raising the aspirations of students as well as raising the profile of STEM to the wider school community. One school commented they 'showcase' the EESW Sixth Form Project in order to 'raise the profile of their sixth form'; with another reporting that students join their sixth form specifically to participate in the EESW Sixth Form Project.

2.2 Quality of collaboration and partnership

The potential reach and impact of STEM Cymru 2 has been dependent on EESW's effective engagement with schools/colleges, employers and universities and the development of quality and sustainable partnerships. This engagement has consisted of publicising the operation to these target groups across eligible areas of Wales and building and sustaining engagement through effective communication. The quality of collaboration is demonstrated by the level of goodwill in relation to the time freely given by employers and universities. Further positive outcomes relating to the quality of partnership and collaboration promoted through STEM Cymru activities, particularly those targeted at sixth form level, are evident in the views of participating universities, schools and employers.

2.2.1 Collaboration between HEIs and schools

For participating HEIs, involvement in STEM Cymru 2 was considered an effective means of promoting facilities and courses to prospective students and engaging with schools within their local communities. The case study 1 extract illustrates perceived benefits to the wider university network; the full case study is in Annex 6.

The potential to develop future students was also highlighted by university staff, with the STEM Cymru 2 activities hosted on university campuses viewed as an ideal opportunity to prepare prospective students with critical thinking and analysis skills. These are skills which both

Case study 1 extract

Some Welsh universities provide facilities and staff to support STEM Cymru 2 activities.

"If all universities do this type of thing, then all universities will benefit. We may not get the students that are here today, but other universities will, and in return we will get those from their events like this."

It is important for the university to help, it is "good to network with industry and important to get into schools early."



university lecturers and employers reported as being a common weakness in school leavers and undergraduates.

University perspective: STEM Cymru 2 provides an opportunity to capture young people's imagination and to inspire them. The activities address the decline in the take up of STEM subjects and encourage girls to take part. They allow students to take responsibility for their work, it is helping to cement their interest in STEM (or making them realise it is not what they want to do, which is important too). STEM Cymru 2 challenges students – their soft skills, their critical thinking, their ambitions to progress and to work in STEM, it provides careers advice as well as technical skills and creative thinking. These projects can influence subject choice, career progression paths, everything associated with promoting and sustaining STEM in schools and universities.

"It [STEM Cymru 2 project] provides good exposure to HE for these students. It's helpful for engagement, they see progression possibilities – it's changing aspirations. It's good for the university too; we forge links with other schools in the area."
(University supporting STEM Cymru 2)

Teachers from participating schools commented on the positive partnerships that have developed with HEIs in Wales as a result of participating in STEM Cymru 2. They provided a range of examples, including the development of close partnerships with specific departments such as engineering and computer science as well as more general links. School students and teachers similarly welcomed the activities delivered through collaboration e.g. the EESW Sixth Form project and Headstart and the opportunity to develop practical, creative and STEM-specific skills using university facilities with the support of experienced staff.

"We are working with one of the most successful electronics departments in the UK. It's a Centre of Excellence; this makes a big impression on students. They see high tech equipment and facilities, it raises their aspirations. They have met lots of employers on the back of their participation – Jaguar, Rolls Royce – it gives students a buzz."
(Physics Teacher)

As well as these skills, progression routes and careers advice were also a key aspect of collaborative activities. Participating students were provided with examples of the career routes taken by previous university students and, in some cases, there were opportunities for participants to discuss courses and careers with undergraduate or

postgraduate research students. The engineers working with the EESW Sixth Form Project groups discussed career paths with students and this was welcomed by students, with one commenting, ‘we have some careers advice in school in year 11 but this is much more hands on and practical.’

“Headstart has met my expectations in every respect so far. There is lots of practical work and interesting lectures. The campus is great, and everything seems very new and up to date. The facilities are really inspiring. The activities are reinforcing my academic knowledge e.g. chemical equations and I am putting this to practical use with the challenges. It’s very hands on and it’s interesting to talk to professors, lecturers and other students – I feel comfortable to ask questions and this is also improving my social skills.” (Male sixth form student)

Having the opportunity to sample university life is a further important element of the collaborative links promoted by STEM Cymru 2 activities. One Sixth Form group praised the interactions they had with their university student mentors with students able to informally ask about careers and higher education options. Female university lecturers and university students supporting Girls into STEM activities were also viewed as providing strong support, particularly for younger students and their teachers who commented on the importance of positive role models in developing an interest in STEM.

2.2.2 Collaboration between employers, schools and HEIs

New partnerships for schools and universities with employers have been created through participation. Most employers consulted referred to the general shortage of engineers that currently exists in Wales and the UK, recognising the need to attract new talent into the industry through schemes such as STEM Cymru 2. This was the most common factor that motivated employers to participate in the EESW Sixth Form Project.

Supporting links with the local community also motivated employers to become involved, as they wished to raise their profile and be seen to be engaging with schools and the promotion of STEM. The opportunity to network and strengthen relationships with the education sector, and universities in particular, was reported by several employers.

Others reported previous engagement with EESW and welcomed the opportunity to be more informed about the calibre of potential local employees, with several linking this to improving staff retention rates. The opportunities for collaboration promoted by EESW has encouraged greater partnership working between industry and universities to strengthen the development of 'industry ready graduates'.

Both employers and university representatives highlighted the importance of critical thinking and problem solving and companies welcomed the opportunity that the EESW Sixth Form Project has offered to bring new ideas e.g. relating to the use of new technologies and potential solutions to genuine problems that companies needed to solve. The case study 2 extract illustrates this with the full case study of STEM Cymru 2 working with Power and Water found in Annex 6.

Case study 2 extract

In 2016 Power and Water supported the EESW project challenge team from Bryn Tawe school, to develop a completely sustainable solar powered water purification system.

In 2017 Power and Water launched the final product which Oxfam has taken on with the intention of using it in Bangladesh where it is expected to change and save lives in areas where clean water is in short supply.



"It's a real-life experience - partnership, teamwork, reaching goals and understanding knock on effects and how small parts of the process affect the bigger production picture and customer expectations." (Employer)

*'It's a positive message, it's challenging students – their soft skills, their critical thinking, their ambitions to progress and to work in STEM. It's providing careers advice as well as technical skills and creative thinking. These projects fit in, they can influence subject choice, career progression paths, everything associated with promoting and sustaining STEM.
(University representative)*

From a student perspective, EESW Sixth Form Project groups interviewed reported the positive impact of the links with industry in improving their STEM-based knowledge. Students developed awareness of different companies and the skills required to succeed in industry through visits to company premises. The timing of visits to company premises at an early stage in the project was important to the students, it meant they were familiar with the problem and engineers suggested the visits helped with decision making regarding the solutions proposed by students.

One school, participating in the EESW Sixth Form Project, commented on the strengthening links between university and industry as projects progress and more contacts are made across the supply chain. Consequently, students meet different employers and expanded their knowledge and understanding further.

A few examples were reported when the engagement between employers and EESW Sixth Form Project participants led to some students being recruited to apprenticeships; supporting the creation of new progression routes. Another school noted that their involvement in i2E has led to a local employer offering an annual apprenticeship for one high achieving student. Several employers also commented that they developed good relations with local university engineering departments and were liaising with them regarding projects specialising in plastic and metals.

2.2.3 Implications for professional development

The collaboration between universities, employers and schools through STEM Cymru 2 has additionally led to positive outcomes relating to professional development for teachers, engineers and university students. Several employers noted the positive contribution of the EESW Sixth Form Project on the CPD of link engineers through the support they provided to the students, with one allocating the time spent by the link engineer to mentor students to the company's CPD budget. Another link engineer commented that mentoring students had influenced his future career decisions; he was now considering moving into training.

Teachers reported that the experiences of visiting company premises and workshops provide them with examples to use during lesson. One school reported that, with the support of more experienced teaching staff, the EESW Sixth Form project provided opportunities for less experienced teachers to become involved in a STEM initiative, supporting professional development in the process.

Following an i2E MicroBit micro processing session one teacher reported that they were now more confident in their own ability to deliver the topic, while another teacher reported that participating had enhanced his knowledge of computer science and progression routes.

Representatives from participating HEIs also commented on the development opportunities that providing mentoring support to EESW Sixth Form Project and Headstart participants provides for their undergraduate and postgraduate research students; particularly in relation to the development of leadership and communication skills. Universities and employers commented they valued the opportunity for graduates, postgraduates, apprentices and other staff being able to develop their leadership /mentoring skills during their engagement with EESW projects. The case study 3 provides an example of this for JCB, the full case study is found in Annex 6.

Case study 3 extract

JCB's involvement in the project contributes to the development of their own apprentices' leadership and communication skills, having a positive impact on personal and professional development.

The apprentice leading the project this year carried out the supporting role last year, and next year the apprentice supporting this year will take the leadership role with a more recently recruited apprentice supporting them.



2.3 Connecting with other STEM activities in Wales

STEM Cymru 2 activities are one of many STEM engagement and enrichment activities that are currently delivered in Wales. Others include activities delivered by See Science, who offer products and services to support STEM teaching and learning, including the STEM Ambassador Programme, Techniquest activities, which include outreach to schools, Science Made Simple and The Bloodhound Project activities which also provide workshops for schools. Schools and colleges consulted noted that it is often difficult for them to identify and distinguish between the range of STEM activities that are available to them. As such, decisions as to which STEM activity to engage with are often based on which ones schools and colleges are familiar with, as opposed to necessarily those which may best suit their specific needs.

Some stakeholders consulted with also commented that the range of STEM activities available can cause confusion for schools, especially with regard to differentiating between the suitability of the activities offered, the costs associated with them, and the potential to integrate them into the curriculum. Despite the abundance of initiatives in Wales, these stakeholders highlighted a lack of synergy and appetite for collaboration and communication between STEM engagement / enrichment providers. In their view, this situation is exacerbated by the lack of a brokering organisation to provide impartial information to schools, ensuring they are aware of all the STEM activities available and the costs they may, or may not, entail.

Representatives from EESW acknowledged that, at a strategic funding allocation level, there appears to be a current lack of coordination or understanding of the range of STEM related activities available. Many initiatives are labelled as STEM activities however they can be very similar or differ widely in their focus and content. It appears to be difficult for schools, colleges and students to identify these similarities and differences.

This has led to calls amongst some stakeholders for greater coordination and integration of STEM activities in Wales. There are also calls from stakeholders for additional efforts to inform and support schools, colleges, and wider stakeholders of the range of STEM activities that are currently available; the activities they deliver and the outcomes they support. Establishing a STEM coordinating body or strategy should therefore be considered as a future priority. It should be noted, however, that a coordinating role of this nature goes beyond the current remit of EESW and the STEM Cymru 2 project. This is a role that should be considered by the Welsh Government.

2.4 Engagement of students

Some stakeholders reported that activities delivered by STEM Cymru 2 enable learners already predisposed and interested in STEM, as opposed to wider engagement with those perceived as 'non-traditional STEM learners'. To some extent this view is supported by feedback received from teachers, regarding the selection

process applied for students to participate, as discussed in section 3.1. Many schools target higher achieving students, who are currently studying STEM subjects. This is perhaps inevitable with the activities for older students, as they have already made their choices at A/ AS level and are now considering progression into further and higher education.

However, there were schools, particularly those engaged in the Girls into STEM and i2E activities who offered participation more widely. As a result, groups contained a wider variation in levels of ability and this approach was considered to have benefits for a wider target group and links to promoting STEM at an earlier age to a range of pupils. One teacher took both pupils eligible for free school meals (FSM) and More Able and Talented (MAT) pupils to a Girls into STEM event at their local university, noting ‘it’s about raising their aspirations to progress to HE and encouraging them to develop STEM-based skills – they’re at different levels but it’s a good way to engage their interest.’ The raising of students’ aspiration is discussed further in section 3.5.

2.5 Progress against output targets

To monitor progress against output targets EESW periodically report indicators of achievement data to WEFO. Table 3 contains STEM Cymru 2’s participation targets.

Table 3: Participation targets for STEM Cymru 2

Strand	Outputs			
	Male	Female	Participants over three years	Female percentage
EESW Sixth Form Project	600	200	800	25%
Headstart Cymru	150	50	200	25%
Girls into STEM	0	1320	1320	100%
Girls into STEM (Extended)	0	270	270	100%
FI in Schools Challenge	420	180	600	30%
Introduction to Engineering (i2E)	990	810	1800	45%
All strands	2160	2830	4990	

Source: EESW (2015) *STEM Cymru 2 Business Plan*, p. 3.

Table 3 also illustrates the importance of positive action to address gender stereotypes, with specific targets for female participation evident, thus addressing equal opportunities, aiming to increase the proportion of females engaged in the study of STEM subjects and pursuing STEM-based careers.

A summary of the most recent monitoring data (September 2017) collected by EESW is presented in Table 4. To date all targets for both male and female participation and completion of training have been exceeded by approximately 30 per cent. The data submitted by EESW to WEFO records 4,714 students participated in STEM activities as part of STEM Cymru 2, 1,278 more than September 2017's target and only 262 short of the total target for the end of this funding period in 2018. Targets for the completion of training have also been achieved to date, and with several months remaining on the STEM Cymru 2 project it is expected this target will be exceeded further. Annex 5 shows the trend in participation and completion figures from September 2015 to September 2017.

Table 4: Targets and achievements up to September 2017

Indicator	Target for Sept 2017	Achieved Sept 2017	Total achieved
Participation in STEM activities – male	1493	2019	4728*
Participation in STEM activities – female	1957	2709	
Training completed – male	881	959	1601
Training completed – female	639	642	

Source: EESW monitoring data. *4,714 participants accepted by WEFO, 14 had missing data on whether they were part of a single adult household or living in a jobless household or not.

WEFO require participants to be included only once in data monitoring, i.e. if an individual takes part in more than one activity delivered by STEM Cymru 2, only the first activity engaged with is recorded and submitted to WEFO. Yet early and continued engagement could be viewed as key to increasing the uptake of STEM subjects both in school, and in further and higher education. EESW record all students who participate in more than one activity and these are recorded under the 'multiple' category in Table 5, which breaks down the participation data for each activity strand, to September 2017, with projected targets for the full term of STEM Cymru 2 also listed.

Table 5: Participation figures by EESW strand, up to September 2017

Strand	Male	Female	Total (up to Sept 2017)	Target (end of project 2018)
EESW Sixth Form Project	443	153	596	800
Headstart Cymru	96	34	130	200
Girls into STEM	0	879	879	1320 (plus 270 extended)
F1 in Schools Challenge	208	130	338	600
Introduction to Engineering (i2E)	1205	1254	2459	1800
Multiple	58	254	312	
Total	2010	2704	4714	4990

Source: EESW monitoring data and Business Plan.

The exceeding of target figures by the i2E strand several months before the end of the STEM Cymru Project demonstrates the positive engagement of schools with this strand. Looking at the participation data for the EESW Sixth Form Project and Headstart Cymru, it is expected that these target numbers will also be achieved. However, it is possible that, when looking at the rate of participation since the beginning of the operation, the targets for Girls into STEM and the F1 in Schools Challenge may not be achieved. There doesn't appear to be any specific reason for any shortfall in the participation target within some of the project strands. In many cases any participation shortfall recorded for one strand is largely offset by an over achievement in participation targets across other strands. As a result, the total participation numbers achieved are only slightly below the target figure (5.5% below).

In addition to this, with further project sessions still being delivered between September 2017 and the end of the current funding period in 2018, the overall participation figures for all the STEM Cymru 2 strands will continue to rise. As a result, any current participation shortfalls are likely to be further narrowed by the end of the funding year.

For some activities such as the EESW Sixth Form Project, the F1 in Schools Challenge and certain i2E activities, the number of participants completing the whole training is also reported. By September 2017, 1,601, completed training, with 2,330 the expected target at the end of the three years.

A further objective for STEM Cymru 2 is to increase the take up of students studying STEM. Efforts made by EESW to collect evidence to record progress against this target have included contacting participating students directly and tracking students

using their unique learning number (ULN). However, gathering evidence in this way has been challenging due to low responses from students and the fact that ULNs are not currently used by higher education institutions. More recently, a system has been introduced to gather destination data of year 13 leavers who have taken part in STEM Cymru 2 activities directly from Senior Management Teams across participating schools and colleges. However, delays in agreeing and implementing the required information collection processes has resulted in some information gaps.

Further to this, the original continuing to study STEM targets were based on the assumption that the figure would include students who continue to study STEM subjects from AS to A level. However, it was decided that only students who progress to studying STEM at level 3 to level 4 and level 4 to level 5 can be included. The combined result of this is that the number of participating students recorded as continuing to STEM is well below the target level originally set. However, the intention in light of these factors is to reprofile this target, and this should come into effect early in 2018. Table 6 presents the current situation regarding progress against targets for those continuing to study STEM.

Table 6: Continuing to study STEM target

Indicator	Target for Sept 2017	Achieved Sept 2017	Total achieved
Continuing to study STEM – male	113	25	
Continuing to study STEM – female	37	5	30

Source: EESW monitoring data.

2.6 Value for money

There are various ways in which value for money achieved by the STEM Cymru 2 project can be reviewed. The first is to consider benefits to the economy less the costs of delivery. It is not possible to robustly estimate the quantifiable economic benefits such as potential future earnings of participants due to associated time lags and external factors that can influence potential future earnings. Indirect economic benefits to participating employers and HEIs are also difficult to isolate and quantify for similar reasons.

Value for money can also be considered in terms of efficiency. Although comparing direct cost per participant (£424 per STEM Cymru 2 participant; if based on the grant awarded it is £332 per participant) with other initiatives may be possible. However, due to the range of activities supported and delivered by the project drawing comparisons with like for like projects is also difficult.

However, the efficiency of STEM Cymru 2 can also be considered in terms of the in-kind support provided by participating employers and HEIs. Participating employers are asked to provide a direct financial contribution to support the project. Employers

also provide the input and time of engineers on their payroll free of charge. This often amounts to several hours of direct support provided by engineers to students participating in the sixth form project. Employers, and engineers in their employment, also freely give up their time to judge entrees to the Big Bang and F1 in schools' events. HEIs also offer the time of their teaching staff, technical support staff and access to facilities such as lecture theatres and engineering workshops free of charge.

The financial value of this in-kind support is likely to equate to several thousands of pounds each year. It serves to demonstrate the value which employers and HEIs place on the project which is reflected in key aspects of project delivery such as quality of collaboration and partnerships outlined in section 2.2 above. In the submission for the grant almost £160,000 was teacher match funded time.

Efficiency cannot be considered in isolation of quality when determining value for money. The evaluation findings outline a number of examples where the quality and flexibility of delivery inputs have been identified (for example, Section 2.1.2) alongside the quality of outputs produced and outcomes generated (for example, Section 2.1.1 and Section 2.2).

Another means of reviewing the efficiency and added value of the project is to consider the extent to which the STEM Cymru 2 project as a whole is greater than the sum of its parts or strands. In many cases the individual strands of the project are delivered in isolation of each other. In some cases, this reflects the different age groups at which the activities are aimed at. However, there is often no obvious connection between the delivery, awareness of, and participation in, various strands of the project when delivered within individual school and college settings.

Schools often choose to participate in one, or possibly two strands of the STEM Cymru 2 project. Many of these schools often appear to be unaware of the other strands of the project that are also available to them. Engagement between the project and individual schools and colleges is often based on contact developed with an individual member of the teaching staff who may have a particular interest in one of the specific strands of the project. This limits the potential reach and appeal of the project across a wider range of abilities and interests amongst students within each school.

Limitations placed on the potential reach and awareness of the project within participating schools and colleges often reflect time constraint and internal communication and coordination challenges within these institutions as opposed to delivery challenges encountered by EESW. However, directing more marketing and promotion of the project to members of the senior manager team within schools maybe one way of addressing some of these limitations.

2.7 Addressing cross-cutting themes

The incorporation of actions to address cross-cutting themes (CCT) are a requirement of all ESF funded operations. The CCTs of equal opportunities, sustainable development and tackling poverty are all addressed by STEM Cymru 2 strand activities.

2.7.1 Equal opportunities

An important emphasis of the STEM Cymru 2 Project is addressing gender stereotypes and breaking down perceived barriers for females considering studying STEM subjects and/or pursuing a STEM focused career. The female only Girls into STEM strand provides female only sessions raising awareness of the potential for females to succeed in the field of STEM. Female role models engage with participants as engineers, graduates supporting workshops at higher education institutions, during visits to employer organisations, and at national competition and award events delivered by EESW.

Monitoring data illustrates all activity strands successfully exceed expected targets for female participation (Tables 3, 4 and 5). The impact of STEM Cymru 2 activities in addressing gender stereotypes is discussed further in section 3.4.

Delivery of the strand activities in both Welsh and English contributes to the Welsh Government's goal for a bilingual nation. When applicable, Welsh speaking staff are allocated to groups during EESW launch events and during workshops. The Big Bang and F1 in Schools Challenge events are bilingual and Welsh speaking assessors are allocated accordingly to schools. Headstart events are attended by both English and Welsh speaking students, as a result it is not possible to deliver the entire event in Welsh. Nevertheless, EESW staff members attending these events are bilingual. Girls into STEM events are delivered by companies, when EESW deliver elements of these activities they are delivered in Welsh for Welsh medium schools. Twelve of the 79 i2E workshops were delivered through the medium of Welsh. Welsh speaking students, particularly those from Welsh medium schools, valued being able to access the STEM Cymru 2 activities through the medium of Welsh. Some students also complete the CREST Award and use their EESW project to contribute to their Welsh Baccalaureate work. If students are from a Welsh medium school, it is important that this work is linguistically consistent. There is potential for EESW to work with the appropriate external partners to ensure such materials and resources are available for Welsh-medium schools.

2.7.2 Sustainable development

Sustainable development is not only a CCT but is also a key driver for Welsh Government policies. STEM Cymru 2 activities provide clear context for sustainable development and contribute to the well-being goals of *The Well-being of Future Generations (Wales) Act 2015*. For instance, innovation demonstrated by students during their problem solving ensures efficient use of resources, equal access to opportunities no matter what an individual's background is clear with the female

focus of Girls into STEM strand, and as highlighted below, the potential to improve well-being is incorporated in many aspects of STEM Cymru 2's activities and outputs.

Raising awareness of sustainable development issues such as energy consumption, recycling and limiting waste are frequently addressed and, in fact, are at the forefront of many STEM Cymru 2 activities. For example, all launch events for the sixth form projects include presentations on sustainability; there are visits to organisations transforming waste material into energy as part of the Girls into STEM strand; practical activities delivered during i2E sessions, powering a calculator using solar power, building a vinegar battery cell and building a wind turbine. All elements of STEM Cymru 2 place an emphasis on the importance of engineering as a means to address environmental challenges, with the resulting products and processes developed supporting sustainability.

Observations of these sessions by the research team have indicated a strong focus on sustainability and engagement from students of all ages e.g. relating to the potential for alternative energy production and supply and developing IT-based solutions to issues facing the environment. For example, as a result of the focus on sustainability, some students go on to submit independent investigations as part of their Welsh Baccalaureate Qualification (WBQ) with a sustainable development focus, and presentations students were tasked with delivering during the First Lego League competition, which is part of the i2E strand, also reflected a sustainability focus.

2.7.3 Tackling poverty

The evidence of STEM Cymru 2 addressing this CCT is not as prominent as the previous two themes. Nevertheless, engaging students in practical STEM activities and delivering related career information to students contributes to raising their awareness relating to employment and progression opportunities and their decision making, as discussed in section 3.5. This may provide motivation for students from the economically disadvantaged regions supported by ESF to progress and determine a career path into higher paid roles.

Some schools reported involving FSM pupils in activities such as Girls into STEM and this can potentially raise aspirations and offer the opportunity for disadvantaged students to develop better skills. The collaboration promoted by EESW between schools, local employers, and universities can also create employment and progression opportunities within disadvantaged communities, offering the potential for greater access to quality jobs for school leavers and graduates. This has been evidenced by the creation of several apprenticeships for STEM Cymru 2 participants.

3. STEM Cymru 2 outputs, results and achievement of targets

This section addresses the perceived impact of STEM Cymru 2 and how efficiently the outputs and results have been achieved. It examines the effect on the soft and industry-specific knowledge and skills developed by participating students, the links between activities and the school curriculum, and the effectiveness of the different strands in achieving their goals, including those relating to female participation.

Key findings

Outputs, results and achievements:

- Schools adopted a range of approaches to recruiting students to participate in STEM Cymru 2 activities;
- Students valued opportunities to consider future study options and careers, with increased awareness of potential STEM careers and motivation levels reported by many participants;
- Students' participation contributed towards the Welsh Baccalaureate Qualification and CREST Award
- Participants reported improvements in a range of practical and soft skills including communication, problem solving, and team work;
- STEM Cymru 2 activities challenged stereotypes, raised females' aspirations and developed their confidence to pursue STEM careers;
- STEM Cymru 2 provided teachers with knowledge and practical examples to support curriculum delivery;
- Improved visibility of STEM in schools was reported by some engaged in STEM Cymru 2.

Several key elements have contributed to the effectiveness of STEM Cymru 2's outputs, results and achievements against targets. Students' motivation to participate, and their expectations before involvement, are discussed, with views of the different activities and experiences for each strand included. Students' perceptions regarding the benefits of participation, including the development of skills achieved and new knowledge and understanding of STEM opportunities for further study and careers, and the extent to which the STEM Cymru 2 activities challenged stereotypes are also considered.

3.1 Student participation

3.1.1 Recruiting participants

The approaches adopted to recruit students for STEM Cymru 2 activities varied. The usual approach was for the link teacher / tutor to target specific groups of students who they considered would benefit most from the experience. For example, in some schools the opportunity to participate in the EESW Sixth Form Project is offered to those studying Physics and Maths or Design and Technology.

Other schools or colleges advertised the opportunity to a wider pool of students requiring them to formally apply. The application and selection process adopted by some schools identified the most enthusiastic and / or more able students to participate. However, given that participation opportunities are limited in most cases, the recruitment processes adopted inevitably resulted in some students, who may have wanted to take part, being unable to do so.

Schools adopted different approaches regarding the selection of participants for the Girls into STEM activities. For example, one school offered the opportunity to MAT students first, whereas another school invited female students with a range of abilities and backgrounds. I2E activities are delivered to a mixture of groups too, with some schools targeting more able students whereas others offered the activity to a whole year group.

In most cases the schools and colleges encouraged the more able and talented students to participate in the activities delivered through the STEM Cymru 2 operation. This is understandable as the tasks associated with activities are often challenging. Students represent their school for the F1 Challenge and Lego League Challenge, which also may explain why more able students are selected to participate. However, as noted in section 2.4, some stakeholders raised concerns about the apparent focus on more able students and considered that it is important to widen access for all students. The example below illustrates a successful example of widening access.

One school, participating on the First Lego League Challenge event in north Wales, reported that they had specifically targeted the project towards students who were becoming disengaged with aspects of school and did not take part in extracurricular activities. The teacher commented that there had been a big improvement in the behaviour and general attitude towards school amongst these students, which teachers attributed directly to their participation in the project.

3.1.2 Student motivation and expectations

Reasons for students' participation in the STEM Cymru 2 activities varied. One group of sixth form students taking part in the EESW sixth form challenge reported they had requested their school to offer them the opportunity to take part, as a result of hearing about the project from friends in other schools. Other students reported the positive experience of older students as encouraging their participation. Participants commented that they listened to the advice of older students and were inspired by the success they had achieved. For younger students participating in the Girls into STEM and i2E activities, several noted they were interested to find out about the topics and looked forward to doing something practical.

Several students reported that teachers provided them with the motivation to take part by explaining to them what the activities would involve. For example, the opportunity to 'see how the world of work operates and a chance to visit a university'. Many older students reported their enthusiasm for taking part was linked to the opportunity to gain an experience which would expand their CV, support their applications for university courses and thus improve their chances of university offers. These students also commented that the activity 'is valued by universities'. The opportunity to achieve the gold CREST Award also motivated several students.

Female student perspective: "I wanted to take part as it looks good on UCAS forms. I enjoyed working as a group and thinking independently. It's quite cool, it's a real-life project. You have a sense of responsibility, you must produce a solution to a problem. Communication skills are developed, you work independently from the teachers too. We had not thought much about software engineering before, it's a more physical side of IT, it's real. The work is helping with my coding skills and being creative. It is interesting to see the university facilities and how you learn independently and are taken seriously."

Male student perspective: “I am really interested in both mechanical and medical engineering – they are different disciplines, so I would like to learn more before making my university choice. It has been a really interesting day – the equipment is so cool, it makes you want to get involved. I’m thinking about working in the medical device industry and the medical engineering session was really good. It has also been great to socialise with other students, everyone is interested and enquiring, and it was good to understand people’s backgrounds. I really liked the mechanical engineering session too, I ‘nerded’ out over the milling machines! The tools and equipment were amazing. The chemical engineering was good too and has links to AS level chemical production.”

Several teachers reported on the enthusiasm of the students to participate in STEM Cymru 2 activities. One teacher noted that students were keen to participate and did not need persuading, with another teacher impressed by the ‘positive attitude and level of independent work’ of the students. Older students interviewed during activities commented that the ‘challenge’ of solving a problem attracted them to take part; with some influenced by the problem presented being ‘local’ and they looked forward to being able to ‘apply knowledge to real situations’, ‘gain additional skills’ and a ‘sense of achievement’. Girls into STEM and i2E participants also recognised that the activities would help them think about future study and career options.

Students participating in Headstart Cymru reported more focused reasons for participation, with several students commenting the opportunity of CAD instruction was the main attraction. They also commented that universities expect CAD experience and the Headstart Cymru event delivered this in a university environment; along with providing students with the information to help them decide which university course to apply for⁵.

“I wanted to look into engineering and see what it was like from a university point of view.” (Female Headstart Cymru participant)

The opportunity to learn about potential careers was a common motivator for students across the different strands. Students taking part in Girls into STEM activities reported they particularly wanted to learn about ‘different types of engineering’. Some of the female students interviewed made specific reference to the lack of females within STEM-based study and employment and used this as a motivating tool for their participation.

⁵ Not all Headstart Cymru events included CAD.

“People say that ‘girls don’t’ and I want to prove a point.”
(Girls into STEM participant)

Although many students reported they understood the level of work required for the Sixth Form Project, there were some groups who noted that the effort required was more than they had expected. They had underestimated the time commitment required and the effort needed to research and interpret complex information. One group of students had not expected the project to result in them missing some lessons to attend activities such as the workshop and a visit to company premises.

A few students were concerned about the potential negative impact on their studies of missing lessons. Another group of students noted that they would have appreciated the opportunity to see examples of previous completed projects at the beginning, as they felt they had been ‘thrown in at the deep end’. There is potential for EESW to make examples available to students at appropriate times during the course of the delivered activities, through for example, case studies or project summaries.

Those participating in an IT based Girls into STEM activity reported that they thought they would be ‘stuck in front of a computer’, ‘talked to a lot’ and ‘doing stuff like maths’ – ‘it would be boring and all technical’. However, most of the participants commented that the actual experience was far more positive than they had expected. They particularly enjoyed the practical activities such as taking a computer apart which they thought was ‘fun’ and ‘far better than being in school’.

3.2 Experiences of participants

Feedback from students relating to their experiences of the different STEM Cymru strands has been very positive. For instance, some female students participating in the Girls into STEM strand noted that they had been able to visit a couple of different engineering settings which meant they were able to compare working environments. As mentioned above, other Girls into STEM students dismantled a computer, programmed a robot and did some coding and these hands-on practical experiences were valued.

“It was fun to learn what it [the computer] is made of and to get things moving” [the Lego robot]. (Girls into STEM participant)

Many students involved in the EESW Sixth Form Project appreciated the opportunity to visit universities for the launch event and/or workshop activity. The visits to company premises were also welcomed. However, a few groups of students reported they would have preferred to have visited the company premises much earlier to enable them to better appreciate the context of their set problem. Visits to companies establish the context of the activity, yet take place at the goodwill of the company

concerned and therefore EESW needs to continue to balance good employer relations with the needs of participants.

Workshops with engineers provided STEM Cymru 2 participants with positive experiences including opportunities to learn in a ‘more practical way’. Students commented that they appreciated the opportunity to develop ideas and apply knowledge with the support of the engineer and university technicians and/or university students. Participating students also noted that they welcomed these experiences as it gave them opportunity to gain real insight into potential academic and career paths.

A few EESW Sixth Form Project groups commented that they had expected the tasks to focus on ‘more traditional engineering’ but they were set projects based on computer software. This in itself can be considered as a positive outcome in relation to its aim of challenging perceptions or misconceptions as to what engineering is and the potential skills and career paths available.

“It’s a lot more practical – you learn from your own mistakes and this makes things stick. It’s real innovation and not fixed to a curriculum idea, our own interests are expressed a lot more.” (Male EESW project participant)

3.3 Benefits of participation

STEM Cymru 2 is set to exceed its participation targets for both males and females (see Annex 5). This is a key output achievement. However, more importantly participants have benefitted in a range of ways from the programme's activities. Some of the key benefits reported by participants of the EESW Sixth Form Project are illustrated in Figure 1.



Figure 1: Benefits EESW Sixth Form Project participants reported

3.3.1 Preparation for university and STEM careers

Students participating in Headstart Cymru commented that the experience had provided a useful introduction and preparation for university. For many students, the course helped them decide the focus for their future studies and which courses to apply for, and in some cases where they wanted to study. These participants also reported a better understanding of possible career routes and roles in industry following presentations during university visits, as well as conversations with engineers, students and staff. The independent way of working at university and being treated 'seriously' during their time there were also appreciated.

*“... by doing the project you understand more about what the job involved, [the project] reinforced I want to do this.”
(Male EESW project participant)*

For one Sixth Form Project group, the focus for their project provided a 'real-world problem' in what is viewed, in one teacher's words, as 'a very abstract course' – computer science. Two student groups reported that they had expanded their subject knowledge as their set problem required more detailed information of areas not

covered by their exam syllabus. The students welcomed this, recognising that they could see how all STEM subjects were used in practice. Other students recognised improvements in their knowledge of the different types of engineering.

One group with an IT focus to their problem, commented that the school curriculum was ‘theory’ and the EESW Sixth Form Project meant they were applying this to ‘real scenarios’. This opportunity to apply theoretical knowledge learnt in the classroom to projects was thought to be very positive – ‘it’s proper work experience’.

Another group of students reported that they had been able to design a solution to their set problem and this gave them a sense of real achievement, especially when a company intended to explore the potential of the group’s suggested solution further. This is illustrated further in case study 2.

In a few cases older participants were keen to apply for apprenticeships with the company they had been linked with. The benefit of participation in supporting student university applications by mentioning students was also important to some. The contribution of participation to support the achievement of the CREST Award and the entrepreneurship and employability element of the Welsh Baccalaureate Qualification were also reported by several students as a benefit. Teachers supported this view with one commenting that those students who had completed the EESW activity last year are ‘streets ahead’ with the employability element of the Welsh Baccalaureate Qualification. The case study 4 extract illustrates an example of the impact of STEM Cymru 2 on the Welsh Baccalaureate Qualification delivery, the full case study is in Annex 6.

Case study 4 extract

Some students choose to focus their individual investigation requirement for the WBQ on a STEM theme, with teaching staff reporting an increasing number of submissions with a STEM focus.

All students created and delivered STEM clubs using EESW supplied resources to achieve the volunteering element of the WBQ.



3.3.2 Skills

Some students noted that they had benefitted from acquiring new skills such as CAD (computer-aided design software) or computer programming skills and the development of transferable soft skills including team working and problem solving. Some students participating in one Headstart Cymru course had never used CAD software before and reported they were now confident to use their new skills in their A level studies.

The development of software-based and more practically-focused skills was noted by EESW Sixth Form Project participants. For example, some students worked with ‘resistors and transistors, building circuits’ and others used specific computer

programmes or wrote a computer programme to solve a solution to a real problem. Students participating in all the STEM Cymru 2 strands also frequently reported improvements in transferable soft skills such as team work and problem solving. Figure 2 presents the skills participants reported they had developed as a result of participating in STEM Cymru 2 activities.



Figure 2: Skills developed by participants during STEM Cymru 2

Source: Feedback from all strand interviews (the larger the font size the more students commented on this skill).

Activities supported by STEM Cymru 2 often encouraged the development of many, if not all, the transferable skills represented in Figure 2 simultaneously. Communication was reported as a key skill development. For example, students taking part in the F1 in Schools Challenge presented their ideas regarding design, gathering sponsorship and the build process at the F1 in Schools Challenge regional events. EESW Sixth Form Project participants presented their solutions to the problem they resolved to a panel of assessors and other interested parties during Big Bang events; and Headstart Cymru participants ‘pitched’ their ideas to fellow students and university staff. All these examples drew on and supported the development of transferable skills.

STEM Cymru 2 activities encouraged students to work collaboratively, introducing them to team building skills in the process. Teaching staff also commented that the ‘soft’ skills developed supported expectations for the Welsh Baccalaureate Qualification and they appreciated the opportunity provided by students’ involvement to put them into practice.

We argued a lot at the start, as we all had different ideas as to how to approach the challenge. Eventually we assigned a leader and worked together as a team. We realised that we all had individual strengths that allowed us to focus on different aspects of the project."

(Reflections from an EESW project student group (males and females))

To enable students to fulfil requirements for the Welsh Baccalaureate Qualification, students from one school reported that they deliver STEM clubs to younger students, providing further opportunities to improve employability skills and volunteering, as illustrated in case study 4 extract. Another school reported that students who had participated in the project were now asking more questions during Science and Technology lessons, which led to more complex issues being discussed during these lessons, demonstrating students' development of critical thinking skills.

Case study 4 extract

An all-female group deliver a Girls into STEM club for 20 year 7-9 girls and four other groups deliver a Key Stage 3 STEM club to 45 students. The clubs run twice a week; 45 minutes at lunchtime and an hour after - school.



For many students, working as a team was an aspect of the STEM Cymru 2 activities that they enjoyed the most; particularly as in most cases it had encouraged them to support each other and work independently with less direct influence from their teachers. Participating in STEM Cymru 2 activities provided many with their first opportunity to work as a team; deciding on roles and responsibilities; drawing on the strengths of individuals and reaching agreement and joint decisions. Being able to 'reach a consensus on ideas' was also something the students found satisfying.

"You think originally, you're not spoon fed."
(Female EESW project participant)

3.4 Increasing female participation in STEM

Equal opportunities is a cross-cutting theme requirement for ESF funding (see also section 2.7.1). A key objective for the STEM Cymru 2 project is to organise specific female events to raise awareness of gender equality and challenge gender stereotypes. The Girls into STEM strand provides targeted activities that contribute to this with elements of the other strands also delivering opportunities to challenge stereotypes. For instance, one teacher reported that over the years the uptake by female students for the EESW Sixth Form Project had increased. Another teacher reported that the level of ability of the female students participating in the activities was above that of many of the males, as a result the 'boys are upping their game to keep up with them'.

Feedback from teachers and students participating in the female focused activities was almost uniformly positive. Students participating in Girls into STEM activities reported that they had expected the activities to be ‘boring’ as that is how they perceived STEM. However, participation in the project had challenged this as the activities were ‘fun’ and they had ‘learnt a lot’ in the process. Most students interviewed expressed positive views about the activities and wider STEM subjects and this suggests that some girls relate more to STEM and engineering activities when they are delivered specifically to female audiences.

Teachers welcomed the opportunity that participating in STEM Cymru 2 activities offered in relation to raising the aspirations of female students to take up STEM subjects. The timing of some of the activities i.e. during years 8 and 9, in the view of a couple of teachers, provided a good opportunity to inform students of (and thus influence take up of GCSE options) the application and potential opportunities associated with STEM subjects. One Girls into STEM project participant reporting that the all-girl sessions are better, as the ‘boys would be too competitive’. Another teacher reported that confidence and attitude of girls improved following engagement with EESW activities.

“I have noticed the year 8 girls we took have grown in confidence in the subject and have put 110% into their work in class.”
(Teacher of Girls into STEM group)

“If I were to go into an engineering job now, I would be excited to show – yes I’m a girl and yes I can do it.” (Girls into STEM project participant)

“The trip seems to have developed their understanding of the subject and their knowledge of the types of careers. They can also see through the female role models they met that it is an industry that is accessible to them and it makes sense to them – they no longer see it as completely alien.”
(Teacher of Girls into STEM participants)

Females participating in the Headstart Cymru project also reported ambitions for engineering; one student enjoyed visiting the different university departments and the experience confirmed that she wanted to go into aerospace engineering. Another noted that she had aspirations to be a civil engineer and that the activities confirmed these intentions as well as increasing her awareness of the types of activities encouraging females to study and work in industry.

Schools participating in the EESW Sixth Form Project use the experiences gained to address elements of the Welsh Baccalaureate Qualification for students. Volunteering is required as part of the qualification and one school reported that all participants would contribute to the delivery of STEM clubs for younger students. These clubs were both mixed and single sex – contributing further to opportunities for other young females to experience STEM activities as a direct result of a school’s involvement with EESW. More detail found in case study 4 (Annex 6).

3.5 Raising awareness of STEM

Links between schools, industry and HEIs were evident throughout the different STEM Cymru 2 strands and feedback collected during strand visits confirmed the impact of such links in terms of raising awareness of STEM for participants.

3.5.1 Enhanced knowledge of STEM

By their very nature, the tasks EESW Sixth Form Project teams are set by their engineers are different, requiring differing emphasis on elements of STEM knowledge and understanding. For example, one team commented that to develop their solution a considerable amount of chemistry knowledge was needed, resulting in independent research to ensure their knowledge and understanding improved. The students discussed how they had found it challenging to research independently, but that the activity helped them recognise how STEM subjects are applied in practice.

Participation in STEM Cymru 2 activities enabled some students to incorporate the experience into other aspects of their STEM-based school work. For example, the independent investigation project is a required element of the Welsh Baccalaureate Qualification. One school reported that following their participation in the STEM Cymru 2 activities the previous year, many of the investigations submitted by students had more of engineering / technical focus compared to investigations in previous years. Case study 4 (annex 6) illustrates this further.

3.5.2 Progression to HE and careers – STEM as an option

Students taking part in the STEM Cymru 2 activities appreciated the opportunity to learn about real examples of possible career routes. In a few instances, the engineers linked to schools were recent graduates. This was viewed positively by students who felt they could relate to the recent university experiences and routes to employment of these individuals as they were quite close to their own age. Companies also commented that their involvement meant that they were ‘better informed about the calibre of students’ from particular schools.

Teachers, students and universities reported that following their visits to a university several students had elected to apply to that university. The students had always intended to study engineering, however, their decision to apply to that university was because they were impressed with the facilities and had enjoyed their visits. They realised that the university was ‘the one for them’. One teacher reported that previous students’ experiences of engagement with STEM Cymru 2 activities had secured offers from universities such as Oxford and Cambridge, who were impressed with the quality of the work students accomplished.

Many students confirmed that having participated in STEM Cymru 2 activities they were more informed regarding engineering as a career option; some examples are included in Figure 3. For instance, prior to taking part, one student’s intentions had been to study Physics – taking part had influenced a change in focus to apply for Applied Physics at university instead. His decision was based on the fact that the

subject would provide him with more opportunities to undertake design and problem-solving activities like the ones he had enjoyed during the project.

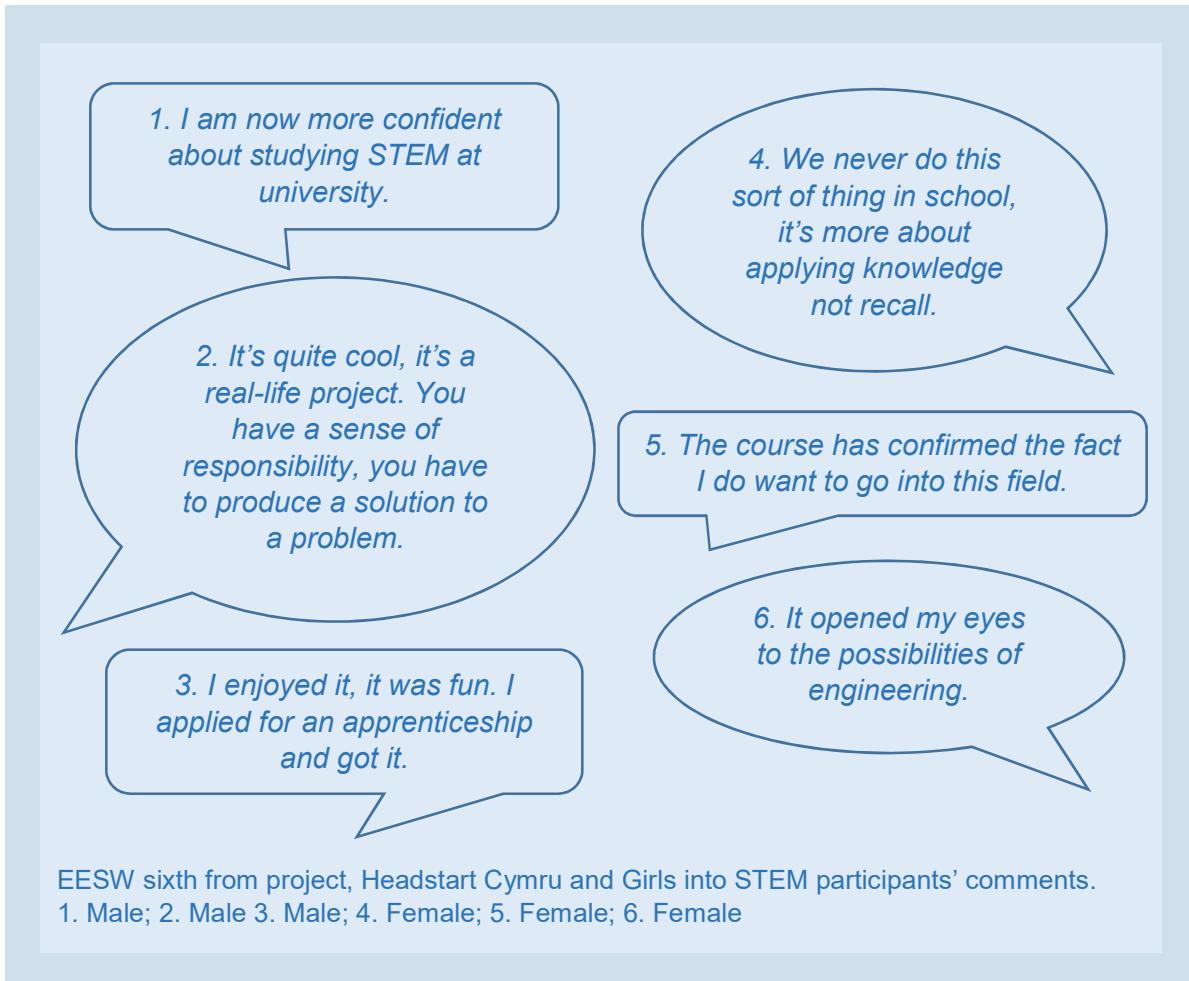


Figure 3: STEM Cymru 2 participants' comments

For a few students, their positive engagement with EESW meant their ideas for future careers were changing e.g. from teaching to engineering. For younger participants the range of potential jobs with the engineering and wider STEM sectors was something they took from their sessions.

"I didn't know about the different career options before and now aware of the shortage of females in engineering."
(Girls into STEM project participant)

3.6 Links to the curriculum

3.6.1 School curriculum

Computer science teachers commented that the activities with an ICT focus complemented the A level computer science curriculum with the problem-solving element that students are provided with boosting skills and helped to ‘cement commitment to the subject’. Teachers discussed that they incorporate examples and ideas gained during the industry visits and workshops into lessons across most year groups.

The Literacy and Numeracy Framework (LNF) is also supported by the different STEM Cymru 2 strands. For instance, i2E and F1 in Schools Challenge activities were designed with particular focus on communication and the use of number, addressing several strands of the LNF. Links to the wider curriculum were observed during an i2E session which focused on alternative energy; the session included Chemistry – chemical reactions in batteries and periodic table; Physics – use of circuit diagrams; Maths – numeracy; Engineering – practical application of the science. During this i2E session students were surprised that it was possible to build a battery using vinegar and nails. Another teacher highlighted the links to work with year 8 students on energy as well as linking to local employment opportunities.

“Having seen how easy it is to arrange these trips and the fact that there is no additional cost involved, we will definitely be arranging more visits next year. It has really enriched the learning experience. It also helps in the classroom as I am able to show photographs and discuss real world issues with pupils, discussing industries that are relevant and local to them.”

(Teacher of Girls into STEM participants)

One teacher attributed engagement with i2E activities to an increase in MAT students, and girls opting for GCSE Design and Technology. Senior management in the school also commented that the EESW activities provided opportunity to incorporate cross curricular subjects and the application of practical STEM activities, which it is not always possible to do in the classroom. One school reported that the prize money, gained from their success in previous STEM Cymru 2 activities, was invested in equipment to enhance curriculum provision in the school.

3.6.2 Welsh Baccalaureate Qualification

Students identified the positive impact of participating in STEM Cymru 2 activities on their Welsh Baccalaureate Qualification (section 3.3) and schools reinforced this, reporting increasing submissions of STEM focused independent research projects and the positive impact on the completion of the entrepreneurship and employability requirements for the qualification. One teacher reported that the reflection required by students to develop their solutions for the EESW Sixth Form Project supported the expectations of reflection needed for the Welsh Baccalaureate Qualification.

See Case study 4 (Annex 6) for further detail about some students delivering voluntary STEM clubs for younger students to fulfil other Welsh Baccalaureate Qualification requirements, demonstrating the wider benefits for a school.

"It's an effective set up. They are encouraged to design and analyse a process. They are using application software, they are problem solving. There is also a boost to presentational skills, report writing, consolidation of learning. All these are embedded into the learning. It's a good tie up to the WBQ reporting and presentation, they can't practice those skills enough."

(Computer Science teacher)

3.7 Directing students towards STEM subjects

A key aim of the STEM Cymru 2 project is to raise the awareness and interest of participating students in STEM and encourage them to take up STEM subjects for GCSE, A level and university study. A criticism that has been directed towards the STEM Cymru 2 project is that it may be targeted towards students who have already chosen to study STEM subjects and therefore, in effect, is 'preaching to the converted.'

This argument does not appear to hold much validity for i2E, Girls into STEM and the F1 in Schools Challenge activities aimed at Key Stage 3 and 4 students for whom maths and science remain core subjects. These students have not yet made any confirmed choices whether or not to study STEM subjects in the future. The STEM Cymru 2 activities therefore provide an opportunity for these students to gain an insight into the practical application of STEM subjects and potential career opportunities associated with them. This in turn may encourage them to consider choosing STEM subjects to study at AS, A level and possibly university.

It is difficult to quantify in isolation the extent to which individual activities supported by the project influence future study and career choices of participating students. However, feedback from participating students suggest that the activities do appear to increase their awareness of, and interest in STEM subjects. One school even used the Microbit i2E sessions delivered to year 8 and 9 students as a means of actively promoting take up of a recently introduce GCSE computer science course.

The argument may however, be more valid when directed towards activities such as the EESW Sixth Form Project and the Headstart programme. These activities are aimed predominantly at students who have already chosen to study STEM subjects at AS and A level or to study engineering as a specific further education course. As such, the STEM Cymru 2 activities can, on first impression, be considered as merely supporting the study choices that these students have already made (see for example section 2.4 above). However, in many cases, activities such as the Sixth Form Project and Headstart appear to continue to have a strong influence on the future study direction and career ambitions of the participating students.

By considering participating students within the broad categories listed below, it is possible to outline examples of how the activities delivered have influenced decisions about future study and career options.

Category 1 - Students studying STEM subjects at sixth form, or a specific engineering course at a further education institution, who have already decided that they would like to study engineering at university and / or pursue a career in engineering.

For these students, participating in the Sixth Form Project and / or Headstart events was not the factor that generated their initial interest in STEM. However, for most, it confirmed their interest and / or increased their enthusiasm for STEM and in some cases helped them decide which specific area they wanted to study or work within in the future. HEIs noted that evidence of participation in STEM Cymru 2 activities also added strength to university applications. In their view, participation in these activities demonstrated genuine interest and commitment to STEM subjects, particularly engineering, providing candidates with a competitive edge to gain a place at their university of choice. Direct contact with employers experienced as part of the STEM Cymru 2 activities also increased opportunities for some students to gain an apprenticeship and / or bursary to support them to study engineering at university.

Category 2 - Students studying STEM subjects at AS level who have an interest in engineering but have not yet decided their future study direction or career aspirations.

For many of these students, the project was their first experience of applying their knowledge of STEM subjects to resolve a practical problem. For some of these students the experience sparked an additional enthusiasm for engineering that prompted their decision to study engineering in the future. On the other hand, for a few participants within this category, participating in STEM Cymru 2 activities enabled them to realise that a STEM based route was not suited to them. This is a valuable outcome for individuals who may otherwise have enrolled onto a university course that may not have been suitable and they may potentially leave early.

Category 3 - Students studying STEM subjects at AS level who have an interest in participating in the Sixth Form Project but are not interested in studying STEM subjects at university

Some participants did not aspire to study a STEM subject at university or pursue a career in the industry. However, they did consider the project as an interesting activity in which their participation would strengthen their application to study other subjects at university. This was a key motivation to participate amongst many students (see also section 3.3.1). However, for some of these students, their participation sparked an enthusiasm for STEM subjects that they did not previously have. This prompted some students to reconsider their study area at university away from areas such as medicine towards engineering.

4. Conclusions and recommendations

This evaluation has been informed by consultations with students participating in the five STEM Cymru 2 strands as well as school representatives, employers, Higher Education Institution representatives and others engaged in STEM activity in Wales. EESW monitoring data has also been included. The following section concludes the evaluation's main findings and proposes recommendations.

Key conclusions

- STEM Cymru 2 has made excellent progress against participation targets;
- The project continues to support and encourage effective STEM-based collaboration between employers, schools, colleges and universities;
- Synergy on a strategic level across all STEM engagement and enrichment providers delivering in Wales could be strengthened;
- The content and focus of STEM Cymru 2 activities complement and support the school curriculum and highlight the progression routes available for students;
- Students and teachers reported benefits for skills and knowledge development. However, it is difficult to demonstrate robust evidence of this with the attainment and progression routes data available;
- Opportunities to participate in STEM Cymru 2 activities are not made available to students of all abilities in some participating schools;
- The project is successfully challenging stereotypes in engineering and raising female aspirations regarding STEM study and careers;
- The project also addresses other WEFO cross cutting themes including sustainability and tackling poverty;
- The project offers good value for money in relation to the amount of in-kind of support it gains from employers, teachers and university staff.

4.1 Quality of STEM Cymru 2 operation and delivery

EESW are delivering quality engagement opportunities and successfully building on previous activities and collaboration. The organisation has built professional relationships with a wide range of schools, individual teachers, FE colleges, universities and employers based on trust and these formed the basis for their operations and delivery. Schools, universities and employers are broadly positive about EESW's management and delivery of the programme and the timing and relevance of activities. Where issues existed, these have related to time and curriculum pressures on teachers and students, which have adversely affected outcomes in some cases.

Progress against participation targets is very good with almost 5,000 participants engaged in STEM Cymru 2 activities. To date all targets for male and female participation and completion of training have been exceeded by approximately 30 per cent. It is expected that the overall targets for the full term of the project will be achieved. There is, however, currently little existing evidence of any increase in the take up of STEM subjects in higher education being attributed to engagement with STEM Cymru 2. This lack of evidence is mainly due to the delays in agreeing the process by which the outcomes will be collected.

It is also difficult to evidence the extent, if any, to which the project contributes to the overall take up and attainment in STEM subjects amongst participating students. It is not possible to isolate or control the influence of the project from other factors that affect take up and attainment. However, anecdotal evidence provided by teachers of participating schools noted an increased interest in and enthusiasm for STEM subjects amongst participating students which can potentially contribute to increases in take up and attainment.

Recommendation for Welsh Government

Welsh Government should work with schools to introduce methods of tracking and monitoring the progression of students with regards to attainment in STEM subjects and their progression routes.

4.2 Effectiveness of collaboration between employers, schools and colleges

Good quality collaboration activities have been supported and have had positive outcomes in terms of CPD, development of local progression routes and engagement with STEM. Participating schools, HEIs and employers have all developed strong partnerships, which have contributed to the delivery of successful outcomes including skills development, awareness of career possibilities, raised aspirations for students and enhanced knowledge for some teachers. The quality of collaboration is demonstrated by the level of goodwill in relation to the time freely given by employers and universities. EESW have addressed collaboration challenges

such as teacher release and budgetary pressures through offering a flexible approach and ensuring relevance to the schools' respective STEM goals and curriculum delivery.

While collaboration within STEM Cymru 2 has been positive there is currently a lack of synergy and co-operation between EESW and other STEM engagement / enrichment providers. This can cause confusion for schools, regarding suitability of activities and the potential to integrate activities into the curriculum and should be addressed in future programmes.

Recommendation for EESW

EESW may need to emphasise to schools the importance of the goodwill of employers and universities in contributing to the success of STEM Cymru 2 activities. At the same time the need for additional support and input from engineers, particularly towards the beginning of the students' engagement could also be encouraged.

Recommendation for Welsh Government

An audit and mapping exercise of enrichment STEM activities should be undertaken. This would give the education sector clarity regarding opportunities for collaboration and provide an overview of activities across Wales.

4.3 Effectiveness across the different strands of activity

Students reported varied reasons for wanting to participate in EESW activities. The opportunity to visit the world of work and engage in something that was 'real' was important to almost all participants. For many, being able to include the experience on their CV, and subsequent university applications, was a key incentive. The challenge of trying to solve problems, gain new skills and having the opportunity to consider possible careers in the STEM sector were also important motivating factors for participants.

Schools adopted different recruitment approaches to engage students in the STEM Cymru 2 activities, with many targeting MAT and students already engaged with STEM subjects. While some schools offered the opportunity to students who were becoming at risk of being disengaged and others provided the opportunity to whole year groups. This reflects a lack of consistency between schools regarding opportunities for students of all abilities to engage.

Students reported the development of practical and softer transferable skills as a result of their participation in STEM Cymru 2 activities. Students participating in the Sixth Form activities reported that they had developed Computer Aided Design skills and other practical skills, along with improving communication, teamwork and problem-solving skills. For this strand and Headstart Cymru students enjoyed being able to experience university life and understand STEM careers better and used it as a motivator for their future ambitions.

Content delivered during the EESW Sixth Form Project supports the curriculum content for A level subjects and elements of the Welsh Baccalaureate Qualification. The lesson content delivered to other students has also been enhanced by the STEM Cymru 2 activities. For example, teachers, who attend site visits and events with participating students, sharing the experiences with pupils in the classroom. Some students also achieved their CREST Award following completion of the Sixth Form Project.

STEM Cymru 2 activities raised awareness of STEM for students across all the five strands, with an improved understanding of the role of STEM in industry and improved awareness of the different types of engineering roles reported.

STEM Cymru 2 activities have also increased the visibility of STEM as activities and achievements associated with the STEM Cymru 2 are publicised internally and externally across participating schools and colleges.

Recommendation for EESW

EESW should ensure case study examples of completed Sixth Form Projects are made available to participants and their supporting staff at appropriate times during the course of the activity.

Recommendation for EESW

EESW should work with schools to deliver larger in-school events. This would ensure students of all abilities have the opportunity to participate in STEM Cymru 2 activities, widening access to STEM studies and potential career routes.

4.4 Efficiency of outputs and achieved results

Content delivered during STEM Cymru 2 activities supports the school curriculum in some cases. In the case of the EESW Sixth Form Project specific A level material is covered, and elements of the Welsh Baccalaureate Qualification supported. Teachers reported using the experiences of the EESW Sixth Form Project to enhance the delivery of lessons for other students.

The focus on being ‘real’ and ‘practical’ proved a key success factor associated with all strands. Students participating in all STEM Cymru 2 activities reported that the ‘real focus’ of the experience was very important to them. The ‘hands on’ practical focus of many of the activities was also appreciated by the majority of participants.

Raising aspirations for other students was possible by increasing the profile of STEM by publicising the STEM Cymru 2 activities and achievements within schools and their communities. The regional award and competition elements are delivered to a high standard and provide a platform for students to showcase their work, gain recognition for their efforts and achievements as well as engage with other STEM activities.

Employers developed partnerships and gained access to the solutions they needed. There are now closer links between the schools/colleges, universities and employers involved as a result of participation in STEM Cymru 2 activities. Some examples of viable solutions to ‘real problems’ have been proposed to employers by the participating student groups.

Recommendation for EESW

The ‘real’ context of the STEM Cymru 2 activities is an important success factor which needs to be maintained in the ongoing delivery of the project.

4.5 Effectiveness of outputs and results in relation to female participation

STEM Cymru 2 has successfully challenged female stereotypes. Some activities are delivered by female engineers and/or supported by females in similar roles and these positive role models are a key aspect of encouraging more female participation in STEM. Female students participating in all the strands, as well as the Girls into STEM focused activities, reported developments in their confidence to pursue further studies and careers in Engineering and STEM related subjects.

Monitoring data recorded by EESW evidences that participation figures for females are being achieved overall. At the time of writing F1 in Schools Challenge and i2E participation targets have been exceeded and with several months until the end of the funding period, these figures will continue to rise.

Recommendation for EESW

EESW should continue to prioritise the support of Girls into STEM, using female role models who direct, deliver and support sessions as often as possible.

4.6 Effectiveness in addressing the cross-cutting themes

STEM Cymru 2 is addressing the cross-cutting themes required through ESF funding. Activities supported under the programme are addressing gender stereotypes and breaking down perceived barriers for females within STEM education and careers. Activities also contain a strong focus on sustainable development through a focus on alternative energy sources while tackling poverty through supporting local employers and universities to create employment and progression opportunities within disadvantaged communities to access quality jobs. The development of local apprenticeships is, in particular, an aspect of the programme which could be built on in future.

Recommendation for EESW

EESW should continue to work with employers and training providers to develop progression routes to allow STEM Cymru 2 participants the opportunity to access quality jobs within their locality.

4.7 Value for money

Given the complex nature of the STEM Cymru 2 operation, it has been difficult to determine value for money. However, our analysis shows that employers and HEIs see enough value in the operations to invest thousands of pounds worth of time, support, and money. This efficiency is also gained without compromise to the quality of the project delivery and the outcomes achieved. Further gains could potentially be achieved if there was closer connection and participation progression between the delivery strands. However, the ability to achieve this is likely to be dependent on the internal operating and management structures of individual schools and colleges rather than the overall management and delivery of the project itself.

Recommendation for EESW

EESW should explore opportunities for closer connection and participation progression between the different strands.

Recommendation for EESW

EESW should market the different strands of STEM Cymru 2 to schools as a package. This would enable senior school staff to understand the connections and opportunities available for different year groups.

4.8 Raising awareness and interest in STEM subjects

Participation in STEM Cymru 2 activities increases enthusiasm for, and awareness of the practical application of STEM subjects, particularly engineering. The Sixth Form Project and Headstart activities appear to provide participating students with an advantage in gaining a place on a STEM related course of their choice at their preferred university. In some cases, these activities have enabled participants to make clear decisions as to the specific area of engineering they wish to study.

Therefore, it would appear that even though a couple of the strands are directed towards those who already study and have an interest in STEM subjects, they do add value in relation to nurturing further enthusiasm and awareness of STEM subjects and improved access to the preferred university courses of participants.

However, recording the number of participating students who go on to study STEM subjects at university has been challenging for the project (see section 2.3 and table 6). Evidence to quantify the impact of the project in this respect is therefore currently limited, although processes are now in place to record this information more systematically.

Recommendation for EESW

STEM Cymru 2 activities should continue to be aimed at students who have already chosen or demonstrate an interest to study STEM subjects in the future, as participation in the activities supports and guides their continued study and career progression in STEM aspirations.

Annexes

Annex 1: Overview of STEM Cymru 2 strands

- 1.1 EESW Sixth Form Project
- 1.2 Headstart Cymru
- 1.3 Girls into STEM
- 1.4 F1 in Schools Challenge
- 1.5 Introduction to Engineering (i2E)

Annex 2: Intervention logic framework for all strands of STEM Cymru 2

- 2.1 Intervention logic overview for all strands
- 2.2 Outcomes for intervention logic for each strand

Annex 3: Interview guides

- 3.1 STEM Cymru 2 students
- 3.2 School/college teaching staff /senior management
- 3.3 HEIs linked to delivery
- 3.4 Employers

Annex 4: Stakeholders consulted and interview guide

- 4.1 Stakeholders consulted
- 4.2 Interview guide for STEM Cymru 2 stakeholder interviews

Annex 5: EESW delivery against targets

Annex 6: Case studies

Case study 1 – STEM Cymru 1 and higher education

Case study 2 – STEM Cymru 2 and employers – Power and Water

Case study 3 – STEM Cymru 2 and employers – JCB

Case study 4 – STEM Cymru 2 and the Welsh Baccalaureate Qualification

Annex 1: Overview of STEM Cymru 2 strands

Annex 1 contains summaries of the activities and events experienced by participants for each of the five strands delivered for STEM Cymru 2 by EESW.

Annex 1.1: EESW Sixth Form Project

This strand of the STEM Cymru 2 project is designed to encourage students to study STEM courses in further or higher education. Local engineering companies set participating teams of year 12 students, research and development briefs related to real industrial problems.

Activities begin in September and October when the company assigned to each team produces a brief defining a problem in the company's operation and tasking the team to produce a suitable solution. The brief is outlined by engineers during the launch event. Typically, the launch events took place at higher education institutions and included presentations from EESW representatives and previous project participants. Activities during the day included team building exercises and videos introducing students to engineering. Participating teams were also introduced to some of the ESF cross cutting themes such as sustainability and encouraged to consider these themes in their solutions.

Each team has up to six months to complete the task, the solution to which should be of benefit to the company. During the development period, students usually visited the company's site and an engineer from the company visited the school. The teams and engineers also attend a two / three-day event at a university or college in December to develop ideas, intending to produce a prototype design. The engineers also provide ongoing support to their teams, often providing opportunity for students to contact them between visits, by phone or e-mail.

The teams produce a written report which is submitted a month before they present their solutions to the company. The teams are given the opportunity to showcase their work during the Big Bang events. The best teams receive various awards at the Big Bang events. Participating teams also have the opportunity to gain a CREST Award⁶. The Big Bang event also includes industry trade stands, interactive STEM workshops, exhibits and careers information. The students, awarded the top prizes, qualify to participate in the national competition at the UK Big Bang event. However, those who succeeded in Wales in 2017 must wait until March 2018 to compete in the next UK national event.

⁶ The CREST Awards scheme is the British Science Association's flagship programme for young people, providing science enrichment activities to inspire and engage 5-to-19-year olds. It is the only nationally recognised accreditation scheme for project work in science, technology, engineering and mathematics (STEM) subjects.

Annex 1.2: Headstart Cymru

Headstart Cymru provides an opportunity for students in Year 12 to spend up to three days at a university prior to completing their UCAS application free of charge.

Students are drawn from several different schools for each course and stay in typical undergraduate accommodation at the university.

The residential courses typically, include tours of the university facilities and short presentations providing information on available courses and potential career pathways. Generally, they aim at giving students a flavour of university life and courses relating to engineering.

During the courses teams of students can be tasked with a design problem e.g. living under water, experience theory and practical sessions delivered by university staff, undergraduates and postgraduates, and use engineering workshop facilities. One Headstart Cymru event provided students with the opportunity to develop Autodesk 360 CAD software skills, at another, students developed electronic circuits, built a raft and learnt about medical engineering.

Annex 1.3: Girls into STEM

This strand includes a series of events aimed at encouraging girls (aged 12 to 16) to take an interest in engineering and STEM subjects as well as IT and computing, to encourage them to consider careers in related areas. Activities supported by this strand include visits to local engineering companies, engineering awareness days and visits to engineering departments in Welsh universities. The content of the information delivered advises students of the lack of females working in these related professions and the lack of skilled individuals in general. Part of the aim of the industry visit events is to challenge stereotypes and misconceptions that engineering is not a career path for females and / or that engineering companies only operate in noisy dirty environments. Students were also presented with examples of potential study and career paths and expected salaries within certain STEM and engineering occupations.

Visits to local companies provide the opportunity for pupils to meet employees to gain and understanding of their background and roles within the company. Participating students also gain an insight into what engineering companies do and experience the different environments within which they operate. The aim is that pupils will appreciate the relevance of STEM in the workplace, as well as become more aware of the career opportunities open to women in the world of engineering.

Within this strand participating pupils may get the opportunity to visit university engineering departments, where they will be given a tour of the facilities and engage with activities under the supervision of university staff. The day is designed to show what university life is like and to encourage girls to consider going to university to study engineering or other STEM subjects.

Annex 1.4: F1 in Schools Challenge

The F1 in Schools Challenge involves school and college students of all ages (up to 19) designing and manufacturing CO₂ powered model racing cars using computer aided design (CAD). Students work in teams to design and create their cars in school, during EESW supported workshops or solely with the support of school staff. Teams aged 11 to 14 participating for the first time enter the Rookie Class which is a simplified version of the Formula 1 Class. All other teams enter the Formula 1 Class which is the original challenge. The different entry levels mean progression is available for teams to improve as their skills develop.

The designs are built using computer numerical control (CNC) machines strategically located at various locations across the WW&V area. Teams are also tasked with gaining sponsorship for their cars from local businesses and, in many cases, incorporating the logos of these companies into the design of the car.

EESW staff offer support, when requested by individual schools, in the design process, including in-school sessions incorporating a series of wind tunnel tests to introduce students to engineering terms and practices including downforce, drag and aerodynamics. The teams are then encouraged to consider how these factors should be taken into consideration in their process of designing the car.

The teams bring their cars and their design portfolios to one of two events held in either north or south Wales where they could showcase the car, the promotional materials they had produced as well as displays showing their design process. Each team also present their designs to teams of judges which includes a five-minute presentation outlining their design process, gathering sponsorship support and building the car. Engineers scrutinise the cars to ensure that they comply with design regulations before the cars are raced along a 20-metre track against cars produced by other teams. Various category prizes are awarded e.g. fastest car, best design. The winners of the north and south Wales regional finals go on to compete at the UK national final for the opportunity to represent Wales at the International Final.

Some of the teams entering the challenge during 2016 – 17 have competed over a few years, using the knowledge and experience they gain from competing one year to refine their design for the next. In September 2017, an all-female team from Ysgol Brynrefail, Llanrug represented Wales in the world finals held in Malaysia.

Annex 1.5: Introduction to Engineering (i2E)

i2E is a collection of activities, designed to stimulate the interest of young people in STEM subjects by providing a task and practical engineering activities delivered to groups of students in their schools or at a company's premises. STEM Cymru 2 deliver a suite of themed activities including:

Energy/ wind turbine sessions

These sessions are aimed at Key Stage 3 pupils and involve teams of up to three students assembling and testing models of wind turbines to demonstrate how energy is transferred. The turbines can be adapted to change the gear layout, blade design, number and size. The aim is to identify the design that produces the most electricity from a wind source. The sessions also incorporate elements of mathematics in determining the design and performance of the turbines.

Another session focussing on solar power and building batteries out of vinegar, copper nails and zinc nails. The students build a battery to power a calculator from a solar power cell. The students also build a vinegar battery cell to power a calculator as well as a series of battery cells to power an LED light. Discussions as to how the alternative energy sources can be applied in practice – focussing on electric cars, also take place during the session.

BBC MicroBit micro processing control sessions

Sessions delivered around this activity focus on programming robots controlled by BBC MicroBits. The robots are programmed to perform various functions including travelling along a set course and producing patterns on papers. These micro processing control sessions also form part of the First Lego League Challenge which some of the participating schools compete in.

Teams from competing schools are challenged to build a Lego robot and programme it, using BBC Microbits, to perform various tasks. Participating schools in Wales can compete against each other during either the north or south Wales regional event. Teams compete against each other to programme their robot to perform a series of tasks such as following a specific route laid out on a specialised board as well as picking up items and moving them from one point to another, teams are judged on their robot's design and programming, each team also research an issue and delivers a presentation proposing a solution, past themes have included animal welfare for example. Teams also attempt a design challenge under the observation of a judging panel. The competition events are facilitated by EESW in association with the Institute of Engineering and Technology (IET) who are the Wales partners for First Lego League (FLL) which is a global science and technology competition for teams of students, to encourage an interest in real world issues and develop key skills to support their future careers.

Annex 2: Intervention logic framework for all strands of STEM Cymru 2

- Engineering Education Scheme Wales Sixth form project (EESW)
- Headstart Cymru
- The F1 in schools Challenge
- Introduction to Engineering (i2E)
- Girls into STEM

Annex 2.1: Intervention logic overview for all strands.

Inputs	Outputs	Performance	Outcomes
<p>Information required:</p> <ul style="list-style-type: none"> • Total value of funding (£) • Funding per participant (£) • Ratio of funding allocated to management & admin / project delivery • Time, in kind and financial contributions of participating employers / link companies when applicable (e.g. Autodesk trainers for Headstart). • Time, in kind and financial contributions of participating HEIs when applicable (e.g. premises / staff time for EESW launch events) 	<p>Information required:</p> <ul style="list-style-type: none"> • Number of activities supported • Number of participating schools • Number of participating students • Gender balance of participating students • Number of participating employers • Number of participating HEIs • Have participation targets been met? • Have targets relating to the proportion of girls participating in the activity been met? 	<p>Information required:</p> <p>Opinions of participating students, teachers, engineers/ employers and HEIs relating to:</p> <ul style="list-style-type: none"> • Delivery - the quality, relevance, and timing of the activities • Meeting expectations – what were participants expecting from the activities / why did they participate / were expectations met? • How effective is the collaboration between the different partners involved (employers/ engineers, schools/colleges and HE)? • How effective are the cross-cutting themes of Environmental Sustainability & Equal Opportunities in relation to the delivery of the strands? • Do the activities supported demonstrate value for money? 	<p>Information required:</p> <p>Impact on:</p> <ul style="list-style-type: none"> • Students • Schools • Employers • HEIs <p>Detail required for each strand presented in Table 2.</p>

Source of information:	Source of information:	Source of information:	Source of information:
<ul style="list-style-type: none"> Project background and monitoring documents and data 	<ul style="list-style-type: none"> Project background and monitoring documents and data 	<ul style="list-style-type: none"> Feedback questionnaires administered by client Interviews during evaluation fieldwork visits to schools, events and employer worksites 	<ul style="list-style-type: none"> Interviews undertaken during fieldwork visits to schools, events and employer worksites

Annex 2.2: Outcomes for intervention logic for each strand.

	Impact on students	Impact on schools	Impact on employers	Impact on HEIs
Engineering Education Scheme Wales Sixth Form Project (EESW)	<ul style="list-style-type: none"> Has EESW increased awareness of participating students of graduate opportunities? Has EESW encouraged participating students to consider engineering as a higher education course to study? Has EESW encouraged participating students who may have previously considered other HEI options to now consider engineering as a higher education course to study? Has EESW increased take up and improved the attainment of STEM subjects at AS and A level? Has EESW enabled participating students to develop other skills? (E.g. team 	<ul style="list-style-type: none"> Is the school's participation in EESW visible across the school? If so has this encouraged other pupils (who have not participated in EESW) to take an interest in engineering / take up STEM subjects at GCSE / A level? Has the school incorporated EESW as part of the Welsh Baccalaureate – if so what impact has this had? Has the school's participation in EESW encouraged the delivery of other activities within the school aimed at stimulating interest in STEM subjects and engineering? How sustainable are the activities and impacts supported by EESW? (E.g. is sustained participation reliant on one key member of staff?) 	<ul style="list-style-type: none"> Have employers utilised the solutions / processes developed by participating students? What difference has this made to product design / business performance? Will EESW lead to a higher calibre of student being recruited into the industry in the future? Has participation in EESW strengthened links between employers and schools? What impact is this likely to have on teachers' knowledge of engineering and technology; and students' awareness and interest in STEM subjects and engineering? Has EESW contributed to developing more effective study and career progression paths for students 	<ul style="list-style-type: none"> Has EESW encouraged greater take up of STEM and engineering HE courses? Has EESW contributed to the development of more effective partnerships between HEIs and employers and schools? Has EESW contributed to developing more effective study and career progression paths for students

	working, confidence, communication)	<ul style="list-style-type: none"> What impact has EESW had on developing new and sustained links between the school and industry / employers and / or HEIs – what benefits to the pupils are likely to arise from this? Has the school's participation in EESW supported teachers' CPD? Would the school have supported other activities associated with promoting STEM subjects and engineering if they had not participated in EESW? 	study and career progression paths for students?	
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	Impact on students	Impact on schools	Impact on employers	Impact on HEIs
Headstart Cymru	<ul style="list-style-type: none"> Has Headstart Cymru given participating students a real insight into studying at a HEI? Has Headstart Cymru enabled participants to make clear decisions as to the focus of HE study? (Did they plan to study an engineering course anyway? if so has Headstart Cymru enabled them to decide which aspect of engineering to study?) Has Headstart Cymru increased participants' attainment in STEM subjects? 	<ul style="list-style-type: none"> Has participation in Headstart Cymru resulted in new skills and knowledge shared with students /staff who did not participate in the intervention? (E.g. CAD skills) If so has this had any impact on CPD for staff and interest of students in other STEM activities offered? 	<ul style="list-style-type: none"> Has Headstart Cymru contributed to developing more effective study and career progression paths for students? 	<ul style="list-style-type: none"> Has Headstart Cymru encouraged greater take up of STEM and engineering HE courses? Are students who have participated in Headstart better prepared to study STEM or engineering subjects at HEI?

	<ul style="list-style-type: none"> Has Headstart Cymru encouraged participating students who may have previously considered other HEI options to consider engineering as a higher education course to study? Has Headstart Cymru provided participating students with an advantage in gaining a place on a STEM or engineering course of their choice at their preferred university? 	<i>Students continued</i> <ul style="list-style-type: none"> Has Headstart Cymru enabled students to develop other skills? (E.g. team working, confidence, communication) 		
The F1 in Schools Challenge	<p>Impact on students</p> <ul style="list-style-type: none"> Has the F1 Challenge increased enthusiasm and interest of students in engineering and STEM subjects? Has the F1 Challenge increased the awareness of students as to how STEM subjects and engineering can be applied in practice? Has the F1 Challenge encouraged participating students who may have previously not been interested to engage with STEM subjects? Has the F1 Challenge increased participants' attainment in STEM subjects? Has the F1 Challenge enabled participating students to 	<p>Impact on schools</p> <ul style="list-style-type: none"> Is the school's participation in the F1 challenge visible across the school? If so has this encouraged other pupils, who did not take part take an interest in engineering / take up STEM subjects at GCSE/A level? Has the school's participation in the F1 Challenge encouraged the delivery of other activities within the school aimed at stimulating interest in STEM subjects and engineering? How sustainable are the activities and impacts supported by the F1 challenge? (e.g. is sustained participation 	Impact on employers	Impact on HEIs

	<p>develop additional skills? (e.g. team working, confidence communication)</p>	<p>reliant on one key member of staff)</p> <ul style="list-style-type: none"> Has the school's participation in the F1 challenge supported the CPD of teachers? If so, in what ways? Would the school have supported other activities associated with promoting STEM subjects and engineering if they had not participated in the F1 challenge? 		
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	Impact on students	Impact on schools	Impact on employers	Impact on HEIs
Introduction to Engineering (i2E)	<ul style="list-style-type: none"> Has i2E increased the enthusiasm and interest of students in engineering and STEM subjects? Has i2E increased awareness of students as to how STEM subjects and engineering can be applied in practice? Has i2E increased participants' attainment in STEM subjects? Has i2E encouraged participating students who may have previously not been interested in STEM subjects to become interested? Has i2E enabled participating students to develop skills? (e.g. team working, confidence) 	<ul style="list-style-type: none"> Has the school's participation in the i2E encouraged the delivery of other activities within the school aimed at stimulating interest in STEM subjects and engineering? How sustainable are the activities and impacts supported by the i2E? (E.g. is sustained participation reliant on one key member of staff?) Would the school have supported other activities associated with promoting STEM subjects if they had not participated in i2E 		

Girls into Engineering	<ul style="list-style-type: none"> • Has Girls into Engineering challenged typical gender stereotypes associated with engineering? • Has Girls into Engineering increased participants' attainment in STEM subjects? • Has Girls into Engineering encouraged participating girls who may have previously considered other HEI options to now consider engineering as a higher education course to study? 	<ul style="list-style-type: none"> • Has the school's participation in Girls into Engineering encouraged the delivery of other activities within the school aimed at stimulating interest in STEM subjects and engineering? • Has Girls into Engineering challenged typical gender stereotypes associated with engineering? • Has Girls into Engineering contributed to closing the participation gap in STEM subjects between girls and boys? 	<ul style="list-style-type: none"> • Has participation in Girls into Engineering strengthened links between employers and schools? • What impact is this likely to have on teachers' knowledge of engineering and technology; and students' awareness and interest in STEM subjects and engineering? • Is Girls into Engineering contributing to addressing gender stereotypes in industry? 	<ul style="list-style-type: none"> • Has Girls into Engineering encouraged more female students to take up STEM and engineering courses at HE?
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Annex 3: Interview guides

Annex 3.1: Interview guide for STEM Cymru 2 students

Background / Process

1. Which EESW strand/s have you been involved with this academic year?
 - *Have you had any previous engagement with the project/s?*
2. How and why did you become involved?
 - *Help to decide whether to study STEM subjects at HE level, learn about different jobs, improve skills and knowledge?*
3. What were your expectations for the project?
 - *Visits, level of work required, skills and knowledge to be gained*

Outcomes

4. Has your knowledge and understanding of STEM subjects changed since your involvement with the project?
 - *Any particular aspects/subject area?*
5. What skills have you developed through your involvement in the project?
 - *STEM-related skills e.g. engineering*
 - *Soft skills e.g. team work, communication*
 - *Has being involved in the project helped with your STEM studies in school? If so, how?*
6. Has participating in the project increased your awareness of progression paths and graduate opportunities through studying STEM subjects?
 - Are you now more likely to want to study and develop a career in STEM in future as a result?

Closing comments

7. What have been the 'best bits' of the project?
8. Are there any parts of the project that could be improved? Please explain/suggest improvements.
9. If you had not participated in the EESW project are there any alternatives offered to you at school/college?
10. What do you think the EESW should offer to schools and students in the future?
 - *E.g. more of the same, specific industry sectors involved, opportunities for further work placements*

Annex 3.2: Interview guide for STEM Cymru 2 school /college teaching staff / senior management

Background

1. What is your role in the school?
2. Which EESW strands have you been involved with this academic year?
 - Any previous engagement with the project – or other similar STEM projects?
3. How did you become involved with EESW and/or particular strand/s?
 - Did you respond to EESW marketing, school always engaged with project, you approached EESW?
4. Did you have any expectations for the project?
 - E.g. engage students – particularly those from under-represented groups, increase interest in STEM, support delivered curriculum and enhance academic performance, opportunity for engagement with local HE/employers

Delivery of the project

5. What did you think of the information you received from EESW prior to starting the project?
 - Did you know what to expect? E.g. amount of time and commitment required / content of activities.
6. What did you think about the organisation, support and communication received from EESW throughout the project delivery?
 - Depends on strand - could only be referring to EESW, if applicable ask about organisation/communication with engineer/employer/HEI.

Impact

Students

7. Has the project/s influenced the general level of interest / enthusiasm for STEM subjects amongst participating students? Do you have any evidence for this?
 - E.g. demand for STEM related clubs / participation in out of school activities
8. Since the project, have girls shown more interest in STEM subjects?
9. Has the project/s influenced the approach taken by the school to deliver STEM subjects?

- E.g. contributing to curriculum delivery – supporting delivery and attainment of WBQ
10. Has the project/s influenced the level of take up and attainment in STEM subjects amongst participating students? Do you have any evidence to support your response, may be male/female differences too?
- School/college (some of these may be more appropriate for SLT)*
11. Did the project/s delivered support the strategic priorities of the school/college?
12. Has the project/s influenced the CPD delivered/required for STEM teaching staff?
13. Has the school's involvement in the project lead to the delivery of any other STEM based activities or projects within the school?
- Is there any sustained impact of the project on STEM subjects, any examples?
 - Has it led to a wider awareness of STEM across the school?
14. If you had not participated in the EESW project would there have been any alternative engagement/activity offered to students?
- Links with industry/universities (if applicable)*
15. Has the project developed and strengthened school/college links with employers and universities?
- Do you have any examples of evidence to share? Employers involved in other aspects of the school/college, access to university facilities.
- Closing comments**
16. Did the project fulfil your expectations?
17. What has worked well and what could be improved upon and how?
- Organisation, time required, delivery, follow up activities, communication, numbers engaged.
18. Are the projects an effective approach to widening access to STEM for all students?
19. What do you think the future priorities of EESW should be in Welsh education?
- E.g. more of the same, engage with teachers to determine needs, deliver CPD for staff, broker links between schools and industry.

Annex 3.3: Interview guide for STEM Cymru 2 HEIs linked to delivery

Background

1. What is your role within your institution?
2. Which EESW strand/s have you been involved with this academic year?
 - Have you had any previous engagement with the project/s or similar STEM-based projects with schools?

Process

3. How did you / your HEI become involved with EESW and/or particular strand/s?
 - *Did you respond to EESW marketing, HEI always engaged with project, you approached EESW?*
4. Did you have any expectations for the project?
 - *E.g. develop school /employer links, links to wider community engagement strategies of HEI, develop future HE STEM students?*
5. How easy has it been to accommodate the visits required for you to the school/ college and vice versa?
 - *Ease of communications, role of EESW project staff, locations*

Outcomes

6. Does participation in EESW projects provide an effective tool for encouraging prospective STEM students and providing them with clear progression paths?
7. Have participating students developed additional knowledge, skills and employability relating to engineering and technology?
 - *Please provide examples*
 - *Any soft skills too e.g. teamwork, leadership?*
8. Do you think participating students are now better prepared to study at the level required at university as a result of EESW?
9. Do you expect the project to have any impact on the number and quality of students applying to study STEM subjects at university?
10. Has there been any impact on school teachers' knowledge of engineering and technology?
11. Have any of the ideas/solutions generated by students participating in the EESW strand of the project been used by your HEI?

- *If so, has the idea generated any financial savings / new research opportunities for your institution?*

12. Has your participation in the project/s had any impact on wider partnership working between HEIs, employers and schools/colleges?

Closing comments

13. If you had not participated in the EESW project would there have been any alternative engagement/activity with schools/employers in STEM subjects?

14. What has worked well and what could be improved upon and how?

- *Organisation, time required, delivery, follow up activities, communication, numbers engaged.*

15. What do you think the future priorities of EESW should be in Welsh education?

- *E.g. more of the same, develop more effective progression routes for STEM, CPD for teaching staff, brokering partnerships between schools, HEIs and industry, work placements.*

Annex 3.4: Interview guide for STEM Cymru 2 employers

Background

1. What is the nature of business for your organisation / your role?

Process

2. How and why did your organisation become involved with EESW?

Outcomes

3. What have been the main impacts for students and teachers?

- *Industry specific and soft skills, knowledge, work readiness, aspirations, impact on addressing gender stereotyping*

4. What have been the main impacts for your organisation?

- *Financial savings/business performance /staff development/new partnerships*

5. What has worked well and what could be improved upon and how?

- *Programme design and delivery, levels of engagement with HEIs and schools, organisation, communication and time required from your organisation etc.*

6. If you had not participated in the EESW project would there have been any alternative engagement with schools/colleges/HEIs?

Closing comment

7. What do you think the future priorities of EESW should be in Welsh education?

- *More of the same, develop more effective progression routes for STEM, engage with teachers to determine needs, deliver CPD for staff, brokering partnerships between schools and industry, work placements*

Annex 4: Stakeholders consulted and interview guide

Annex 4.1: Stakeholders consulted

Director of a Science Communication Company (Science Made Simple);
Director of the STEM Learning contract holder for Wales (See Science);
National Officer for Wales for the Institute of Physics;
Head of Education within a national science centre (Techniquest);
Head of Core Subjects Branch at the Welsh Government.

Annex 4.2: Interview guide for STEM Cymru 2 stakeholder interviews

Background

1. What is your job role?
2. Are you aware of EESW?
 - a. If yes – how did you become involved with EESW? Motivation for involvement? What has been /is the nature of your involvement with EESW?

STEM Cymru 2

3. Are you aware of the different STEM Cymru 2 strands/projects, such as *Girls into STEM, Introduction to Engineering, F1 Challenge, Headstart, EESW 6th form projects*?
(Interviewees may answer this in Q2, but they may have only referred to EESW as an organisation, detail about specific strands is needed)
 - a. Please explain involvement e.g. involved with one particular strand, sponsorship, assessing EESW, brokering links with industry, specialist subject/technical support.
4. How effective do you think the collaboration is between the partners involved in the different strands (employers/ engineers, schools/colleges and HE)? Any examples?
5. To what extent do you think EESW and the STEM Cymru 2 strands support young people to study STEM **and** pursue careers in STEM?
 - a. E.g. target particular groups for projects/visits (e.g. girls), supporting the curriculum, links with industry, highlighting routes into STEM careers (HE/ apprenticeships/ traineeships), any examples?
6. What impact is STEM Cymru 2 having on encouraging girls into STEM? (Any examples)

STEM and the wider context

7. How does STEM Cymru 2 address the wider agenda of supporting young people into STEM? Prompts:

Priorities from: ‘*Science, Technology, Engineering and Mathematics (STEM) in education and training: A delivery plan for Wales*’ (2016)

- Developing fit-for-purpose STEM curricula
- Enhancing and enriching STEM curriculum
- Introducing fit-for-the future STEM qualifications
- Advice, guidance and teacher support
- Provision of bilingual resources
- Wider ICT support
- Developments in higher education
- Changing perceptions
- Reinforcing the importance of STEM
- Careers advice and guidance
- Women in STEM

Themes from: ‘*Talented women for a successful Wales*’ (2016)

- Education in STEM subjects
- STEM workforce - Recruitment and retention
- STEM – leadership and role models

Future priorities

8. What are the future priorities for encouraging young people into STEM in Wales and what is EESW’s role?

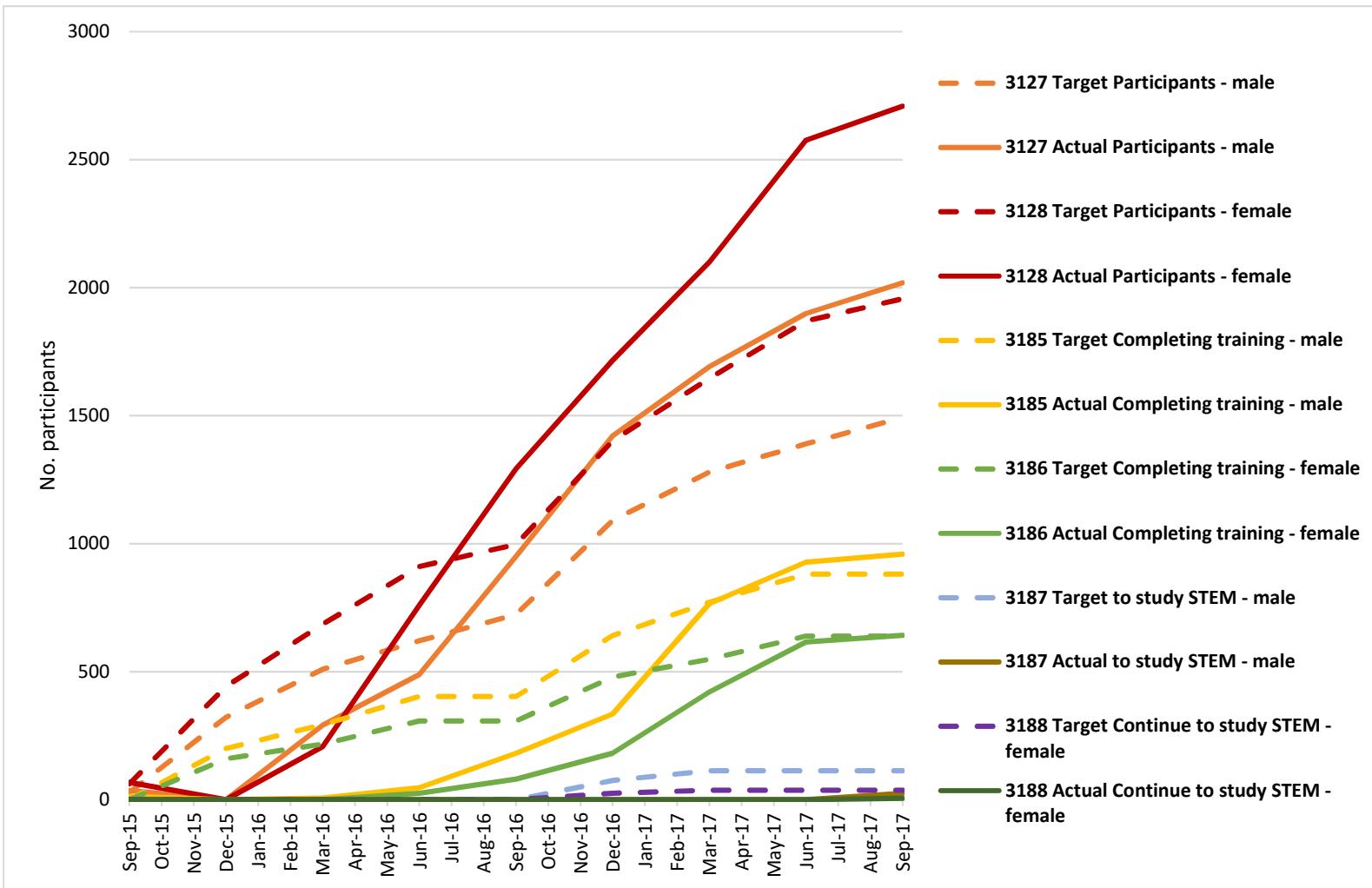
- a. Prompts – more of the same, CPD for teachers, brokering partnership links between industry and education, careers guidance for students, supporting curriculum content/delivery (e.g. Welsh Baccalaureate Qualification).

9. What would the landscape of STEM in Wales look like without EESW and the STEM Cymru 2 strands?

- a. Prompts – Uptake of STEM subjects, challenge to gender stereotypes? Are there other bodies currently delivering similar activities or able to deliver activities?

10. Any further comments?

Annex 5: EESW delivery against targets



Source: EESW (3127, 3128, 3185, 3186, 3187, 3188 are WEFO target references)

Annex 6: Case studies

- Case study 1: STEM Cymru 1 and higher education
- Case study 2: STEM Cymru 2 and employers – Power and Water
- Case study 3: STEM Cymru 2 and employers – JCB
- Case study 4: STEM Cymru 2 and the Welsh Baccalaureate Qualification

Case study 1

Some Welsh universities provide facilities and staff to support STEM Cymru 2 activities

"If all universities do this type of thing, then all universities will benefit. We may not get the students that are here today, but other universities will, and in return we will get those from their events like this."

It is important for the university to help, it is good to network with industry and important to get into schools early."

STEM Cymru 2 and higher education

Background

Most of the strands delivered by STEM Cymru 2 are supported by Welsh higher education institutions. STEM Cymru 2 participants have opportunities to use university facilities, work with graduates and staff, and learn about university courses and career pathways.

STEM Cymru 2 activity

Both Headstart Cymru and the EESW Sixth Form Project provide sixth form students with opportunities to use university workshop facilities while developing their ideas with the support of university students and staff. In some cases, universities are the ‘employer’ and set the challenge for the project, which results in more frequent engagement with a university. Sixth form students participating in Headstart Cymru stay in university accommodation. Some of the ‘Introduction to Engineering’ and ‘Girls into STEM’ activities also use university engineering and information technology facilities, again supported by university students and staff.

Impact of STEM Cymru 2 activity

Universities reported involvement in the STEM Cymru 2 activities contributed to local community engagement activities, opportunities to market courses to potential students were provided and university students were role models supporting participants’ aspirations. Delivering activities to school students also provides university teaching staff with an understanding of children’s current skillset. Supporting the projects, during the delivery of the project and at the Big Bang Award days, also contributes to university students’ professional development.

Sixth formers particularly enjoyed visiting university campuses, using the workshop equipment, and learning about other university facilities and the courses available. As a result of their experience, sixth formers attended open days and one university reported receiving at least two applications for STEM-related courses from each group of students participating in the EESW project. Some younger students (year 10) participating in ‘Girls into STEM’ activities on a university campus also reported that before visiting the university they had not been sure about whether to go to university but visiting the campus had convinced them university was for them.

Employers also welcomed the opportunity to develop ongoing partnerships with universities and schools.

Case study 2

Students are a sounding board for innovative ideas

"Young people often interpret industry problems differently to the way we do. This is enlightening, it keeps your mind fresh."

"Developing an idea, taking it to product and presenting it to industry experts - this is the skillset required to succeed in our industry. The difference is, these young people get to experience this while they're in school, most don't get to do this till their 20s or 30s."

STEM Cymru 2 and employers – Power and Water

Background

Power and Water is a water technology company specialising in the recovery of waste products, and the production of clean, safe water for drinking, re-use or discharge back into the environment.

STEM Cymru 2 activity

The company first became involved in the STEM Cymru 2 project when the CEO, Professor Philip Morgan, was informed of the project by one of EESW's area coordinators. He was immediately interested as it gave him the opportunity to give back some of the support from industry that he had received when he was a student.

Impact of STEM Cymru 2 activity

The EESW Sixth Form Project tasks supported by Power and Water aim to encourage practical application of chemistry and physics – '*converting theoretical principles into practice*'. Professor Morgan reported noticeable improvements in the young people the company supports each year – improvements in overall confidence and enthusiasm, as well as their academic and practical application.

Participation in the project has also benefitted the company. The problem-solving ideas developed by the students are often very different to those that Power and Water typically come up with themselves. This encourages the company to challenge its own approaches to developing solutions which, according to the CEO, '*keeps them young*' and '*keeps their minds fresh*'. This year a team from Bryn Tawe school is developing a mechanical, wind-up powered water treatment system. The opportunity to support and mentor the students also provides valuable management CPD opportunities for the Power and Water staff assigned to support the young people throughout the project.

Wider impacts of STEM Cymru 2

In 2016 Power and Water supported the EESW project challenge team from Bryn Tawe school to develop a completely sustainable solar powered water purification system. In 2017 Power and Water launched the final product which Oxfam has taken on with the intention of using it in Bangladesh where it is expected to change and save lives in areas where clean water is in short supply. Power and Water noted that they would not have participated in any STEM related projects if they had not been approached by STEM Cymru 2. They intend to continue to support the EESW Sixth Form Project each year.

Case study 3

JCB

Two JCB apprentices support students to complete the EESW sixth form project.

JCB apprentices “develop their leadership and communication skills.”

Students learn to work from a company’s job specification; to a timescale and budget, “all useful preparation for work.”

The EESW project “has always worked for us, we could facilitate one more group.”

STEM Cymru 2 and employers – JCB

Background

Across the UK JCB employs more than 6,000 people, with more than 400 based in north Wales, including nine apprentices. The north Wales JCB factory builds axles and gear boxes for many of the machines that are manufactured at JCB’s Staffordshire site.

STEM Cymru 2 activity

JCB has contributed to the EESW project for many years. Two JCB apprentices support school or college teams throughout their engagement with the project. One of the JCB apprentices currently supporting the EESW project experienced the project as a student and reported that it helps being similar in age to the participants. The apprentice remembers the process well and understands when additional support is needed and the importance of explaining terms so that students understand.

Impact of STEM Cymru 2 activity

Students participating in the project with JCB reported on the importance of the factory visit, as they experienced ‘the real design process’ and this helped them to appreciate that ‘the design process is back and forth and back and forth’. JCB personnel also reported the students develop their teamwork and leadership skills, and gain experience of working from a company’s job specification, which requires them to work to set timescales and within budget constraints, which are all ‘*useful preparation for work*’. Following involvement in the project some students go on to successfully complete work experience placements with JCB and some of the current apprentices at JCB completed the EESW project as students. JCB’s involvement in the project contributes to the development of their own apprentices’ leadership and communication skills, having a positive impact on personal and professional development. The apprentice leading the project this year carried out the supporting role last year, and next year the apprentice supporting this year will take the leadership role with a more recently recruited apprentice supporting them.

Continued engagement with EESW

JCB welcome the opportunity to follow up some of the completed student projects. JCB apprentices engage in many community activities as part of their role, involvement in EESW is part of this, which also include supporting careers events and the Wales GB Rally, and providing tours of the factory.

Case study 4

STEM Cymru 2 and the Welsh Baccalaureate Qualification

Students requested that the school participate in the EESW project.

The number of STEM focused individual investigations for the WBQ is increasing.

To complete the volunteering element for the WBQ the sixth form students deliver STEM clubs for at least 65 younger students twice a week.

STEM Cymru 2 and the Welsh Baccalaureate Qualification

Background

Croesyceiliog Comprehensive School, Torfaen, contacted EESW to find out more about the EESW project. During sixth form entry interviews students had referred to friends in other schools participating in the project, and they wanted to be able to have the opportunity too, commenting that it would '*broaden horizons*', '*is valued by universities*' and they would '*gain additional skills*'.

STEM Cymru 2 activity

Teaching staff selected 21 students studying STEM subjects to participate from the 47 who expressed an interest. The launch event for the EESW project was at the school and students, split into four groups, began to work on their set projects. In December 2016 the groups attended Cardiff Metropolitan University for two days and worked with their allotted engineers to develop their ideas further. All groups submitted their final reports and attended the Big Bang Award event in south Wales (April 2017). One group won the 'best written report' category and all students who wished to achieve the Gold CREST Award were successful.

Impact of STEM Cymru 2 activity

Skills - Students reported that the project had improved their communication and team working skills. As they were using real problems this supported the theory studied in school. Students were also positive about the opportunity to learn more about different career routes during the project.

The Welsh Baccalaureate Qualification (WBQ) - Some students choose to focus their individual investigation requirement for the WBQ on a STEM theme, with teaching staff reporting an increasing number of submissions with a STEM focus. Students created and delivered STEM clubs using EESW supplied resources to achieve the volunteering element of the WBQ.

Wider benefits - An all-female group deliver a Girls into STEM club for 20 year 7-9 girls and four other groups deliver a Key Stage 3 STEM club to 45 students. The clubs run twice a week; 45 minutes at lunchtime and an hour after school. Some of those delivering intend to continue the clubs after they have achieved the 30 hours volunteering required for their WBQ. The school and EESW are currently exploring the possibilities of delivering an enterprise project to KS4, as students are asking for opportunities like the Sixth Form Project.