Welsh HE-Centred Engineering Outreach
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Abstract
The project was designed to build on existing success of the Welsh Engineering Project (WEP) and the work of the Engineering Education Scheme in Wales (EESW), to extend and add value to outreach activities by increasing interest in Science Technology, Engineering and Mathematics (STEM) in particular, Engineering. It was also structured to deliver a range of activities to increase and widen participation and provide better progression through the phases of education, with a specific focus on encouraging girls to consider engineering as a possible future career.

It was also designed to increase the involvement of HEIs in Wales in STEM related outreach activities and working with school pupils.

Keywords: outreach, engineering, increase participation, widen participation, girls.

Background
The Engineering Education Scheme in Wales (EESW) has operated for 21 years and has built up a reputation of excellence in linking bright sixth form students studying STEM A levels with industry to work on real engineering problems. This has affirmed the desire of many students to enter engineering as a career and has also encouraged others to re-consider their future. Prior to the call for proposals for the National HE STEM Programme, EESW had extended its activities, through the WEP, to include earlier phases of education from Year 5 (8-9 years old) up to the sixth form (16-19 years old).

Rationale
Wales, like the rest of the UK and most of Europe, needs to increase the number of school pupils taking STEM subjects with a view to increasing those opting for engineering as a career. In addition to professional engineers, there will be a requirement for an increase in the numbers of technicians and apprentices. A recent SEMTA (SEMTA, December 2010) report pointed out the need for about 354,000 employees within its sectors in the UK to replace employees retiring during 2010-2016. After taking into account the expected decrease of 122,000 jobs across SEMTA’s sectors over this time period, there will still be an overall net requirement to fill about 232,000 jobs (around 32,000 per annum).

There is expected to be a net requirement for 120,000 jobs across the mature engineering sector, 86,000 jobs across the leading-edge technology sectors and over 25,000 jobs for the science industries during 2010-2016. Focusing on technical roles, there is expected to be a net requirement across SEMTA’s sectors in the UK for nearly 114,000 engineers, scientists and technologists (over 16,000 per annum) during 2010-2016.

This project is designed to increase interest and widen participation in STEM activities with the direct involvement of HEI students and academic staff. It is intended that it will leave a legacy of quality activities that will continue beyond the life of the project. Through a basis of sound
engineering activities, all of EESW’s work encourages the development of STEM subjects through contextualised learning in applied engineering activities.

**The Approach**

The aims of the project were to:

- Show schools pupils that taking STEM subjects, specifically engineering, is important to the future prosperity of Wales.
- Ensure engineering is seen as a subject that is of strategic importance to universities in Wales.
- Encourage more pupils into HE engineering courses.
- Widen the participation of pupils from all socio-economic backgrounds.
- Encourage more female students into engineering as a career.

The director of EESW and the National HE STEM Programme Welsh Spoke based at Swansea University worked together to organise the following outreach events.

**Training/Briefing sessions for HE engineering departments**

The central thrust of the proposal was to involve HEI students and academic staff in engineering outreach activities within the schools and colleges in Wales. Five training sessions were held and overall 32 people from 6 universities attended. Most of the attendees were academics with, in some cases, post graduate researchers. A seventh university was involved later.

The programme for the training days was set up in close consultation with the National HE STEM Programme Welsh Spoke at Swansea University. The day addressed the following issues:

- An overview of the current curriculum and structure in Welsh schools.
- The issues related to STEM uptake in schools and colleges.
- The role and purpose of HEI involvement with EESW portfolio of activities.
- The particular skills and experience HEI students and staff can bring to the project.
- Contacts with schools and companies and how to improve communication with them.
- EESW and what activities it offers to schools and colleges.
- Targeting and working with female students.

The training day also encouraged debate about the ‘skills agenda’, employability skills and the need to bring schools and HEIs closer together. The portfolio of outreach activities (described below) was presented and university staff and students were invited to take part to link with schools and in some cases partner companies. This was organised by involving individuals from the HEIs with regionally based activities.

The feedback from the academics (including some post graduate students) who attended was that they felt that they had a better understanding of the Welsh school system. The sixth form students, who attended the link events, felt that as a direct result of engagement with the EESW activities they had a better understanding of what higher education can offer them. Each HEI representative attending these sessions was given the opportunity to develop closer links with schools and industry.

Creating new links with schools and pupils were more successful than creating new links with industry and new academic contacts within the HEIs. The reasons cited for not getting involved, were mostly due to the pressure of work commitments. For academics, the lack of recognition for outreach was also cited as a reason for not getting involved with outreach activity. Undergraduates worked with (through providing technical and project management support) school teams following the awareness raising days and academic staff were involved in most universities at events such as the **F1 in Schools Challenge** (a Formula One themed national science & engineering
competition) final event and sixth form workshops which took place at HEIs and FE Colleges. Academic staff got involved in a number of ways; some provided technical advice or making presentations at the different events or judged the students’ work at the F1 in Schools Challenge final.

At the initial training sessions, part of the discussion involved the need to recruit more girls to study engineering at university. As a direct result of these discussions, it became apparent that academics were interested in finding out more about how they could engage with female pupils in schools and how they could support female undergraduates and post-graduates.

Following the HE Engineering Department training sessions, the Widening Participation and Outreach Officer at Swansea University organised a Gender Equality Workshop and offered the academics the opportunity to attend it. Two workshops were arranged, one in the North at Glyndwr University and one in the South at Cardiff University. They were organised with the help of the heads of engineering and nominated staff at each university.

The one day Gender Equality Workshops were facilitated by the UK Resource Centre for Women in Science Engineering Technology (UKRC), as they had developed a similar workshop which had been successfully trialled through the London Engineering Project.

The workshop aims were as outlined below:

- Raise awareness of gender-based attitudes and knowledge amongst staff
- Raise awareness of the benefits of, and the business case for, a positive approach to gender equality in SET
- Improve recruitment, progression and retention of women in SET
- Raise awareness about the factors influencing access to Higher Education in SET subject areas
- Identify actions that SET employees in HEIs can take to apply learning from the training
- Produce more inclusive publicity and marketing materials
- Develop the academic research base by ensuring female talent is not lost
- Improve teaching and learning and ensure inclusivity

The workshop agenda was to look at:

- Barriers preventing women’s recruitment and retention in STEM
- Women's experiences and perceptions of STEM – case studies and good practice
- Promoting Change – practical steps towards improved recruitment and retention.
- Gender and the law
- Action planning

A total of 19 academic staff from various universities across Wales attended these sessions. The portfolio of outreach activities were:

**Primary Bloodhound Challenge (for students in Years 5 & 6, 10-11 years old)**

This Primary Bloodhound Challenge has particular relevance in Wales due to Swansea University engineering department’s direct involvement with the Bloodhound SSC project. Staff and students were invited to attend the Regional finals and in some cases worked with school teams. Approximately 500 primary pupils were involved with the challenge. Members of the Swansea Bloodhound engineering team addressed the pupils at the South Wales final at Swansea Maritime Museum. This project allowed EESW, with the help of the Widening Participation and Outreach Officer at Swansea University, to have greater involvement with postgraduates, undergraduates and lecturers from the HEIs across Wales. This was achieved through inviting academics, postgraduate and undergraduate students to help and support the teams in school and also helping with the judging at Primary Bloodhound Challenge final or simply just attending the final event. EESW already had contacts in universities offering engineering courses and in conjunction with the Widening Participation and Outreach Officer at Swansea strengthened these contacts.

**Attracting girls into engineering (Year 12, 16-17 years old and Years 8 & 9, 13-15 years old)**
In order to further increase the involvement of girls in the engineering profession, it was proposed to extend the pro-active programme piloted in the WEP which was designed to inform girls of the many and varied routes available to them within engineering. This was achieved through arranging visits for girls to environments that would encourage a positive view of engineering. This included a visit to Airbus UK (which was hosted by female engineers), engineering activity days organised in conjunction with the army and visits to engineering companies related to areas that might be of greater interest to girls, e.g. cosmetics manufacturing. As well as having female engineers to work with girls on projects that link with industry and the F1 in Schools Challenge, specific visits and activities were arranged to demonstrate the opportunities that exist for females in the STEM sector. By introducing mathematical concepts through engineering outreach students are not only shown how to apply this knowledge, they are also shown engineering in context and therefore how engineering can be an exciting and rewarding career.

EESW consultants were recruited to organise these visits, they also acted as chaperones on the day of the visit and also organised the transport for getting the students to and from their school to the engineering company.

**Linking HE Engineering Undergraduates and Lecturers with sixth form outreach activities (Years 12 & 13, Sixth Form, 16-18 years old)**

EESW has a very good track record of engaging bright sixth form students with industry to consolidate their STEM subject expertise and encouraging them to continue with STEM subjects in higher education and, in particular, to study engineering. In 2010-11, over 400 students participated from a total of 52 schools across Wales. As part of this project, HEI students and staff were offered the opportunity to become more closely involved by helping to improve the interface between the AS level students, the participating companies and the individual HEI departments. Academic staff where closely involved with the sixth form students at workshops and Headstart Cymru which are STEM experience courses at university. Undergraduates were also linked to EESW teams and assisted the sixth form students with their projects by visiting the schools and providing knowledge of complex engineering issues.

**Evaluation**

Activities were monitored closely by seeking feedback from students, teachers, university staff and undergraduates, and by completion of student questionnaires.

Views of students and teachers:

- “My pupils had a valuable experience and a window on a grown up inspiring world which they would not otherwise see in their school life.”  *Teacher - Ysgol Gyfun Garth Olwg*
- “The confidence they get from here they take back into the classroom.”  *Army Careers Officer*
- “I always know that I wanted to do something with science and this confirmed it.”  *Student - Ysgol Gyfun Llanbedr Pont Steffan*

Some views from participating HEIs:

- “The Awards Event is an ideal opportunity to raise awareness of the University.”  *Open University*
- “A lot of students are interested in the undergraduate offer and we can see a direct take-up.”  *Cardiff University*
- “From UCAS and the number of applications that participated in this we know that the event is well worth it.”  *Cardiff University*
- “Collaboration with schools, the students and the teachers work with our technicians.”  *Cardiff University*

Due to the relationships previously developed with HEIs and schools there were no difficulties in organising this strand of the project.

Through the Primary Bloodhound Challenge more than 500 pupils were involved in designing and racing model Bloodhound cars. The winning teams went forward to the UK national finals held at the Big Bang in London. Welsh schools gained 1st, 2nd and 3rd places. The team finishing in first
place were from a very small primary school on the island of Anglesey; they are now the UK champions. Approximately 33% of the participants were female. Four HEIs were directly involved with the activity with major events taking place in three HEI locations.

Over 350 girls took part in the 'attracting girls into engineering' visits and activities specifically designed to encourage an interest in engineering. This strand was originally targeted at sixth form level where we achieved 23% female participation. To increase female participation we chose to recruit pupils from Years 8 and 9 (13-15 years old). It was also felt that working with pupils at this age, we could have a greater impact on career choice, as this is the age prior to when pupils make decisions about which subjects they study at GCSE Level. 30% of students who attended girls’ events agreed that they were more interested in engineering and science after the visit.

The positive effect on the girls’ attitudes towards engineering was clear from the feedback questionnaires, such as “Girls and boys can do engineering” and “I’ve learnt how many different types of engineering jobs are available”. After the events, 86% of girls agreed that they now know what engineering was all about, compared with only 32% prior to the visit.

Students visited companies including Rookwood Hospital Engineering Department, Alberto Culver and the Royal Mint. In some cases, visits were to such environments that were perceived to be more interesting to girls. The organiser felt that if girls were introduced to engineering, related to societal or environmental issues, girls may be more interested in engineering in general. It was felt that it be would be of more interest to all the students to make them aware of the role of engineering, using simple everyday items such as cosmetics or mobile phones. Where possible the visits featured presentations and tours conducted by female engineers. 92% of the female students agreed that they know more about engineering after participating in Girls into Engineering events.

Teachers and providers commented that girls were found to be more at ease in single sex groups and engaged with activities in a less inhibited way, which was reinforced in the feedback from the girls. One commented that “teamwork with girls from other schools...built my confidence”. Both teachers and pupils have requested that more of these visits and activities be made available in future. The percentage of girls who agreed they would like to take part in other engineering activities increased by 27% after participation.

Through linking schools with HEIs, 438 sixth form students attended induction days in universities or FE colleges across Wales. The celebration event at the project took place at two prestigious venues in both North and South Wales. HEIs were invited to attend both in support of pupils and to promote themselves to the future applicants. Also, as a direct result of the contacts made, over 90 students took part in a Headstart Cymru residential course at two Welsh universities where they experienced broad engineering disciplines offered at HEIs. An added bonus was the involvement of undergraduates from four universities working with the sixth form students which was an unplanned outcome from the additional contacts made. They acted as good role models representing the HEIs and provided valuable expertise to support pupils’ activities. The pupils were able to relate to the undergraduates and were able to find out more about studying STEM at university. Of the AS level students who participated in EESW in 2010-11, 61% said that they were more likely to study STEM subjects further into A Level and higher education.

**Discussion**

In its report, *Getting Girls into Engineering: A Practical Guide*, The Royal Academy of Engineering reports that, “The UK and the wider world are facing a shortage of engineers and scientists; the very people needed to preserve and improve our planet and our well-being”.

OFSTED in its *Girl’s Career Aspiration* report published in April 2011 concluded that:

- From an early age, the girls surveyed had held conventionally stereotypical views about jobs for men and women. They retained those views throughout their schooling despite being taught about equality of opportunity and knowing their rights to access any kind of future career.
- Careers education was generally weak in Key Stage 3. This made informed choices of courses and careers difficult.
Discussions with teachers and Careers Wales confirm that we need to intervene at earlier stages of pupils’ school life to inform and influence important decisions made later. The Wellcome Trust in its report, *Subject Choice in STEM: Factors Influencing Young People (aged 14–19) in Education* published in October 2010 point out that, “Some of the most crucial choices relate to their education, in particular what combination of subjects they decide to take for higher level study. For most young people such choices take place between the ages of 14 and 18”. In England (and Wales) they are likely to be asked to make selections at 14, when they decide which GCSE courses they are to pursue. Helping young people to make the most appropriate subject choices is therefore crucial, both to ensure that the country has the skills it needs for the economy and, to enable young people to make the best choices to meet their own future needs and aspirations.”

These views influenced the decision to shift the emphasis for attracting girls into engineering from 6th form level to girls at a younger age where the activities should have a longer lasting effect, and will help to improve a wider target audience of girls involved in STEM subjects in the sixth form. The low uptake of A Level maths, mentioned earlier, also influence the decision to intervene at a younger age.

The project was effective as it offered increased opportunity to engage with HEIs which helped strengthen EESW’s efforts in encouraging students to study STEM at a higher level. To build upon this, EESW aims to continue seeking further support from the universities and their staff through HEI co-ordination.

The motivating and contextually-based activities were something of a revelation to some HEI students and staff with some commenting that they wish they had been offered the opportunities when they were in school. For girl’s engagement there were successes in HEIs that provided good role models with an effort to demonstrate the breadth of engineering available, in particular focusing on those areas which appeal to girls.

The involvement of HEIs in activities such as induction days, hands-on workshop days and Bloodhound final days helped to promote STEM subjects amongst pupils and provided important links with HE for other activities including *Headstart Cymru*.

Overall, the project is deemed to have been a great success; however there are some areas for discussion arising from conversations with teachers and pupils. There is still work to be done in promoting engineering as a great career as there are still prevailing myths about what an engineer is. Many of the anachronistic, stereotypical perceptions have a detrimental effect on increasing the number of bright pupils who might consider engineering as a career. Teachers felt that the need for A level maths is a barrier for many students who would otherwise make ideal engineering candidates. Generally, it was also felt that educators need to work with HEIs focus to help them not just focus on creating links with sixth form students but to create links with primary and secondary schools, where we can have greater impact of changing their student perceived ideas about engineers and a career in engineering.

**Further Development**

From the point of view of EESW, there will be further development with HEIs and existing partnerships will be sustained and extended through continued involvement with other activities. EESW will continue to work with the HEIs, industry and schools to find funding and/or sponsorship to keep the project running.

In particular, EESW aims to continue running the Headstart Cymru course with continued support from HEIs and will aim to seek further support from additional HEIs in Wales to allow for an expansion of this successful event.

Whilst recruiting students for our activities, we realised that it was going to be much more difficult to recruit sixth form girls due to the relatively low uptake of STEM subjects, particularly in mathematics and physics. We would like to have a greater impact on this, which we have tried to influence this year by targeting girls at a younger age “Although on average girls outperform boys in all subject areas at key stages of assessment, proportionally fewer girls than boys progress to study SET (science, engineering and technology) subjects at A level and in higher education.” *The Royal Academy of Engineering, Getting Girls into Engineering: A Practical Guide 2009.*
However, this is a complex situation with a number of external factors influencing career decisions. It would be interesting to look further at where there should be similar interventions before the age of 14, whether interventions of this type would have an effect on their chosen career path. If so, this may help to increase the amount of girls who take A Levels in maths and physics.

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