



Diversity in engineering

Summary report

Exploring the inspirations, aspirations and destinations of potential engineers by gender, ethnicity and socioeconomic background

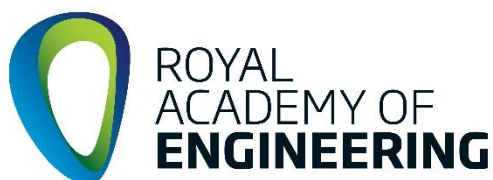
Sean McWhinnie and Jan Peters

About this summary

Data originally collected as part of the HE STEM Set to Lead¹ project have been updated and considered along with student's backgrounds. The work has examined the differences in transition rates from studying to working in engineering and technology and advocates a need for targeted action for students on bachelor programmes. In understanding the messages to be conveyed to schools the importance of social, global and problem based learning is advocated alongside a campaign to connect engineering with girls both visually, aurally and physically.

This work was produced for the Women's Engineering Society by Sean McWhinnie in association with Jan Peters, funded by the Royal Academy of Engineering.

Supported by



© 2014 Women's Engineering Society. All rights reserved.

The material in this report may be reproduced and disseminated without infringing copyright provided that the following acknowledgement is given:

Diversity in Engineering: Exploring the inspirations, aspirations and destinations of potential engineers by gender, ethnicity and socioeconomic background. Reproduced by permission of the Women's Engineering Society.

¹ Set to Lead was funded by the HE STEM project and delivered through a collaboration of UCL and Katalytik in association with Oxford Research and Policy. The project set out to investigate and address the differences in the transition between men and women from engineering and technology degrees into relevant employment. As part of the project a survey of engineering and technology undergraduates was undertaken. The SET to Lead report and resources were published in 2012. Full details and reports are available at: <http://katalytik.co.uk/projects/set-to-lead/>

Foreword by Meg Munn MP



There is no doubt that the career paths of women differ from those of men and tend to be more disrupted. Making connections across key transition points on the path to an engineering career is something that the Women's Engineering Society (WES) has done throughout its history; passing on the knowledge, wisdom and excitement of what lies ahead.

This summary report extracts the key messages from the larger WES, *Diversity in Engineering* report.

The HE STEM funded *Set to Lead* report contained the voices of over 4,500 engineering and technology students, including 1200 women. Twelve hundred contributions of the experiences, passion and commitment to studying a vibrant and useful subject and I'm delighted that the Society has been able to secure funding to extend this to ensure those voices are heard.

The support of the Royal Academy of Engineering has further enabled an examination of the *Set to Lead* data in more detail, update it, and add more context in terms of the socioeconomic background and aspirations of the next generation to inform our strategy.

Importantly making sure that experience of undergraduates is heard by teenagers is vital so they can understand the opportunities available and the passion felt, both of which may give them the incentive to explore engineering while at school.

The design agency that produced the output poster, supported by focus groups, advocated making strong, repeated and clear associations between "girl" and "engineering" and produced the following straplines:

"It's time for engineering girls" and "Engineering, it's in everything"

The Society is keen to see a higher level, coordinated engagement strategy in order to present a clear and consistent message and offer an engagement programme for girls, whether in a single sex or mixed sex activity.

What strikes me about the report's findings is that while the diversity and engineering agenda broadens out to address other dimensions of diversity, it is clear that once students have made the transition to higher education to study engineering and technology subjects, **gender is a more significant factor than social class in determining occupation types.**

We need all the groups and organisations promoting engineering and technology as a career to make efforts to address this.



1 Introduction and methodology

This summary report highlights the findings from considerations of the key transition stages of young people from school to engineering and technology courses in higher education and from undergraduate course in higher education to employment and/or further study. The report highlights areas for possible interventions to help break the **accumulated disadvantage** felt by women and BME graduates on engineering and technology higher education courses.

The data in the full report are focused on higher education entrants and graduates. Similar issues to those highlighted in the report exist in further education with low participation rates for women and black and minority ethnic men and women on engineering and technology apprenticeship programmes.

The first part of this project involved further analysis of data originally collected for the SET to Lead project during December 2011 and January 2012 through a link emailed to 53 Higher Education Institutions. Once the data were cleaned a total of 4624 responses remained for analysis. Data provided by the Higher Education Statistics Agency (HESA) were also analysed. Specifically the HESA standard registration population, the HESA qualifications obtained population and the HESA Destinations of Leavers from Higher Education (DLHE) target population were analysed. The analyses focused on the influences of gender, ethnicity and socio economic background.

The second part of this project aimed to share the 'voices' of early career engineers and women engineering students with younger women to help share their experiences and promote diversity of engineering both in terms of the people who do it and the job roles and industries they can work in.

The free text responses collected in the Set to Lead survey were revisited and supplemented by a series of focus groups held at Sheffield Hallam (SHU), Aston and Cardiff Universities. Participants were sourced using WES student members and student groups and staff at SHU and Cardiff. An online survey was also launched to try and capture inputs from students with parents who do not work in managerial jobs and have never been to university. Nineteen students took part in the discussions.

Information from the literature also helped to contextualise some of the findings.

2 Why is this topic important?

Retention of women in science, engineering and technology (SET) is an important issue, with economic and social justice implications. The overall retention rate of female SET graduates is far lower than that of males, 25% compared with 40%.² The situation, which contributes to the relative lack of women in senior positions in SET professions, is sometimes described as "the leaky pipeline"; as scientists and engineers flow along the science career pipeline – a notional path representing training and advancement – they "leak out" and are lost to science.³

Girls who study science A Levels are more attracted by medicine and pure science rather than by engineering and technology higher education courses. Possible explanations for this include a lack of role models and stereotyping by parents, teachers and society of careers suitable for girls. Convictions about

² Report for the Office of Science and Technology and the Department of Trade and Industry, *Maximising Returns to Science, Engineering and Technology Careers*, London: DTI, 2002.

³ N. Angier, Women Swell Ranks of Science, But Remain Invisible at the Top, *New York Times*, May 21, 1991.

girls' suitability for engineering study and employment are dispelled by their academic achievements and yet still find their way into the media. And girls lack an identity with engineering.

The full report presents the results of an analysis of Higher Education Statistics Agency (HESA) data on qualifiers in engineering and technology subjects and of the Destinations of Leavers from Higher Education (DLHE) of the same group of students, with a particular focus on ethnicity and socio economic class. In addition, the report presents the results of a survey of engineering and technology undergraduates with a focus on the responses of respondent by ethnicity.

3 Key Findings

The main findings, conclusions and recommendations are presented below, covering the career aspirations and destinations of undergraduates and an exploration of the key influences for teenagers that in turn affected the content of the WES poster, "Engineering, it's in everything", available from the Society.

3.1 The analysis of HESA and Survey Data

The influence of parental background

Analysis of HESA data showed a few clear patterns and some points of note:

- Students of engineering subjects are **more likely** to have parents with higher managerial and professional occupations than students of technology subjects, and in turn students of technology subjects are **more likely** to have parents with higher managerial and professional occupations than students of computer science subjects.
- Students' parents' occupations have little influence on post-graduation activities for male or female students completing enhanced engineering first degrees (e.g. four-year first degree courses leading to MEng qualifications). However students' parents' occupations do affect the graduates from bachelor first degree engineering and technology courses (e.g. three-year first degree courses leading to BEng or BSc qualifications) main activities six months after completing their courses.

Influence of gender

Analysis of HESA data showed that:

- Men are significantly more likely than women to be in engineering and technology roles six months after completion of their studies, and the difference grew between 2007/08 and 2009/10.
- Women from bachelor engineering and technology degree courses are significantly more likely than male graduates to enter non-graduate level jobs.
- Gender differences between the main activities six months after graduation are greater for bachelor degree graduates than for enhanced first degree graduates.
- For bachelor degree graduates, within the engineering, technology and computer sciences subject group there is little variation of activity and occupation six months after graduates complete their courses for each classification of students' parents' occupation.
- With each classification of students' parents' occupation gender differences are observed in the activities and occupations of graduates six months after graduates complete their courses for the engineering and computer science subject groups, with men more likely than women to be in engineering and technology occupations. The gender differences are much smaller for technology subject group graduates. For example, among engineering bachelor degree graduates with parent in higher managerial and professional occupations, 67% of males are in engineering and technology occupation compared to 52% of females. In contrast, 32% of males and 43% of females are in non-STEM occupations.
- Overall the data suggest that **gender is a more significant factor than social class in determining the graduate occupation types of graduates from engineering and computer science subjects.**

The influence of ethnicity

Analysis of HESA data showed that:

- White students are significantly more likely than BME students to be in full-time paid work: 68% of White male graduates from enhanced first degree courses in engineering were in full-time work six months after completion, compared to 49% of Asian male graduates.
- Higher proportions of Asian graduates than White graduates were undertaking further study. Similar patterns are observed for Black and Chinese graduates from enhanced first degree courses in engineering.

Analysis of the survey data showed that:

- BME UK nationals are less likely than White UK nationals to have undertaken some form of work experience during engineering and technology degree courses. Although the numbers are too low to draw any firm conclusions, the analysis also suggested that final year BME respondents had spent less time than White respondents undertaking work placements and/or internships during their courses.
- Overall 87% of UK national respondents were paid during their most recent work placement or internship. There were significant differences between the responses of White and BME male respondents.
- BME respondents are less likely than White respondents to have spent time working in an area relevant to their courses before starting their course.
- BME respondents in their final year were less likely to have undertaken a placement as part of their course, and/or an internship than White respondents. While on placement, BME respondents were less likely to have met a role model who inspired them, and they were less likely to be paid than White respondents.
- White male respondents are more confident about their possession of technical skills than BME male respondents, and both White and BME female respondents. This difference in confidence may differentially affect the career decisions of the different groups.
- Respondents ranked how important different factors were in their future careers:
 - Both White and BME survey respondents rank "A workplace culture where all staff are treated well" as the most important factor in a future job.
 - "A strong health and safety culture", was ranked 18th by White respondents and 9th by BME respondents, and "A strong equality and diversity culture" was ranked 20th by White respondents and 10th by BME respondents.
- Overall there is little difference between the knowledge of career options of White and BME survey respondents at undergraduate stage.

Discussion and conclusion

The Set to Lead research report highlighted the differences between the employment destinations of male and female engineering and technology graduates. Although survey data suggested that men and women had similar career intentions with respect to gaining employment in engineering and technology roles, HESA data showed that men were more likely than women to be in engineering and technology roles six months after completing their courses. The survey data also showed that men were more confident than women in their technical abilities and in their ability to make a good engineer or technologist. The suggestion is that the greater "career confidence" of men results in them being more likely to apply for and secure engineering and technology roles. The data also showed that undertaking good quality internships

or work placements increased the confidence of both men and women, but that the confidence gap between the genders remained.

The analysis of HESA data as part of this project suggests that BME graduates from engineering and technology courses are less likely than White graduates to gain first or upper second class degrees. Even when the degree class of graduates is taken into account, White graduates with first or upper second class degrees are more likely than BME graduates with first or upper second class degrees to be in full-time paid work six months after completing their courses, and of those that are in work, White graduates are more likely to be in engineering and technology and graduate-level roles.

In contrast, the socio economic class of graduates, as measured by their parents' occupation, appears to have little effect on the attainment of graduates or on their destinations. In fact a graduate's gender, or whether or not they graduated from an enhanced or bachelor first degree course, affects their destination more than their social class. There is evidence that social class is a determinant in whether or not an individual enters higher education, but the evidence, at least for engineering and technology graduates, is that social class is not a major factor in determining employment in engineering and technology roles.

White and BME respondents appeared to share similar motivations for undertaking engineering and technology courses, and appeared equally likely to state that they intended to seek employment as an engineering /technologist or undertake further study in engineering/technology. Also, there was little difference in the knowledge of career options of White and BME respondents, and for the most part White and BME respondents ranked factors important in their careers similarly.

White respondents in their final year were more likely than BME respondents to have had some relevant work experience before undertaking their course, and were significantly more likely than BME respondents to have undertaken at least one work placement or an internship. The reasons for the differences are not known; especially as White and BME respondents were equally likely to have work placements as part of their courses. The implication is that where placements are optional BME students are less likely to take them up and that BME students are also less likely than White students to obtain internships. Whether BME students are less likely than White students to apply for the internships, or whether they are less likely to be offered them once they have applied, is unknown.

The survey data also suggest that male and female BME respondents are less confident in their technical abilities than White male respondents. The BME respondents share relatively low confidence in their technical abilities with White females.

Overall the survey data do suggest that BME respondents are less likely to have relevant work experience than White respondents, and that they also have less confidence in their technical skills than White male respondents. These data might go some way to explain why BME graduates with first or upper second class degrees are less likely to enter full-time or part-time work, or to enter engineering or technology roles than White students.

Looking at the whole picture though, comparing White and BME graduates, BME graduates are less likely to gain first class or upper second class degrees, and they are less likely to have relevant work experience, and have less confidence in their technical skills. Findings from the survey might go some way to explain some of the differences in patterns of activity six months after White and BME graduates complete their courses.

In contrast to the findings for ethnicity, and as noted above, social class does not appear to be a major factor in degree class or activity on graduation.

In conclusion, the findings suggest that while gender and ethnicity are factors in attainment and subsequent employment of engineering and technology graduates, social class does not have a major effect.

3.2 Girls and career aspirations

Literature research was undertaken to understand better the key influences on teenage girls' career aspirations and that was supplemented by discussion groups comprised of teenage girls and of female engineering and technology undergraduates.

- The undergraduate discussion groups were convened to learn more about how students' backgrounds affect their decision to study engineering or technology and to collect advice that they might wish to pass on to aspiring female engineering and technologists still at school.
- The discussion groups comprising teenage girls were held to learn more of the effect of the girls' background on their attitudes to studying engineering or technology, and also to gauge their reactions to materials prepared for the "Engineering, it's in everything" campaign.

The ASPIRES project⁴ identified two types of girls who express science aspirations. "Bluestocking scientists" refer to themselves as "kind of nerds" that like studying. A smaller number of girls, who balance their interest in science with a more "girly" identity of fashion, being sociable and sporty, are termed "feminine scientists".

A framework for identifying target groups of girls for interventions was developed for this project based on descriptions in the literature and on the field work carried out as part of the project.

Girls can be grouped into those that naturally have a positive predisposition and attitude towards engineering and technology subjects – the "**do**" group - and those that "**don't**". Girls in the "**don't**" group may be capable in STEM subjects. Among the "**do**" group are those who "**will**" go on to follow a path that leads to STEM A Levels and possibly to the study of engineering or technology beyond compulsory education. Some of the "**do**" group, however, have clear ideas of careers outside engineering and technology such as wanting to be a doctor, lawyer or part of another clearly identified profession and hence "**won't**" go on to engineering or technology careers.

Among the "**don't**" group there are girls who have clear ideas of careers outside engineering and technology and hence also fall into the "**won't**" group.

There is also a group from among the "**don't**" girls who "**could**" follow engineering and technology paths. This group is of particular interest: they are the girls that "**could**" follow engineering or technology careers as they are capable in STEM subjects, but whose personal identities and influences are very different from the "**do**" group and consequently do not have a positive predisposition towards engineering and technology.

The main challenge is to engage the "**could**" group in discussion and debate during the critical period between year 5 and year 8 (ages 8 to 13) so that they have an innate awareness of what engineering is about.

⁴ ASPIRES Project Final Report , *ASPIRES Young people's science and career aspirations, age 10 –14*, Kings College London, London, 2014, (<http://www.kcl.ac.uk/sspp/departments/education/research/aspires/ASPIRES-final-report-December-2013.pdf>)

A subsidiary challenge is to ensure that members of the "will" group also have the detailed knowledge and awareness to make the best choice of course in the event that they choose to follow an engineering or technology path and become "do" girls.

More generally, findings suggest that teenage girls:

- Have little knowledge about engineering or engineers;
- Believe engineering is for people who love mathematics and science;
- Do not understand what engineering is but they do understand that it is not "for them";
- Want a job with relevance – suggesting a job "for someone like me";
- Want to hear about careers and match how they align with their own career motivators: enjoyable, good working environment, making a difference, good income, flexibility.

Counter to this:

- Career influencers including educators are often not familiar with how to guide students towards engineering and are not receiving positive stories of engineering for their female audience;
- Engineering continues to be portrayed as challenging and with a less confident audience this does not fit with the personal identity of the "could" girls.

There remains a knowledge and communication gap that is preventing girls from entering engineering compounded by class and ethnic background cultural preferences for female occupations. The "Engineering, it's in everything" campaign and the supporting WES website offering insights into planning your career is part of the action to close the gap. **But more is needed.**

The general findings, and in particular the defined groupings of girls, helped to refine the target audience for the "Engineering, it's in everything" campaign poster:

- To enable the "will" girls to have a wider appreciation of engineering
- To connect with the "could" girls.

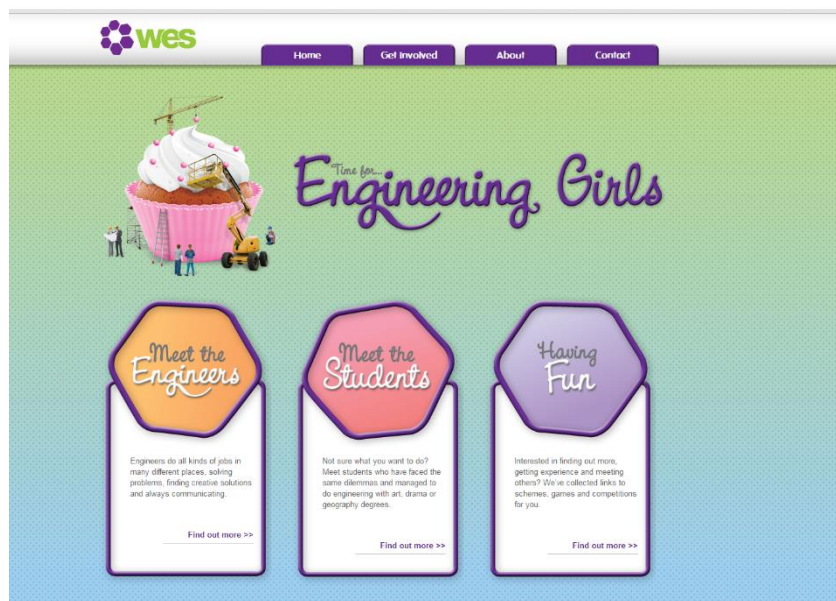


Figure 1: Image of the WES Engineer Girl website



Figure 2: Image of the front and back of the poster, "Engineering, it's in everything"

Discussion and conclusion

There is a body of research that discusses how girls' attitudes to STEM subjects and careers vary from boys'. Girls' choices are to a degree influenced by their self-identity and how the image that they have of a particular subject and career fits with that identity. The more familiar girls are with STEM subjects, and the kind of careers that they might lead to, the better able they are to make objective choices. Such familiarity might be gained through having a parent who is a professional scientist or engineer, or having contact with an inspiring teacher. Such contacts are likely to be scarcer for girls from more deprived backgrounds or other backgrounds where contact with STEM professionals is less likely.

It is therefore important that better quality information about modern engineering and technology is made available to girls at the age when they are developing their self-image and thinking about future careers, and in a way that allows girls to see engineering and technology as compatible with themselves as individuals. Importantly this information needs imparting in the formative years when girls still engage with science to the same extent as boys, i.e., in school years 5 and 6.

The "Engineering, it's in everything" poster and website, in part informed by the findings of this study, is one attempt to communicate with young women in a context with which they identify. One poster won't change the attitudes and views of young women in school. But repeated associations of words, positive connections and refreshing images updated and disseminated through multiple channels can help engage and then offer the potential to inspire more girls from diverse backgrounds to consider and appreciate engineers and engineering and perhaps come to believe that engineering is a career for them.

The framework suggested highlights key target groups of girls and suggests delivering initiatives in a way that engages with them in an appropriate manner earlier than is currently done – in years 5 to 8 in a connected manner with common messaging.

In addition girls planning for university need further information about subject choice and the variation in degrees available.

4 Bridging the gap – recommendations for action

Our recommendations for action to bridge the gap, involve several stakeholders:

Target: KS2 and KS3 school students

- There should be greater interaction with STEM Ambassadors and exposure to discussions about jobs and roles in engineering and technology with explicit reference to women as an imperative to challenge stereotyping using action based language.
 - *Stakeholders: Employers and teachers*

Target: KS3, KS4 and KS5 school students

- Access should be improved to information, case studies and STEM Ambassadors with information on the diverse nature of roles, skills needed and routes into various engineering and technology jobs.
- In association with STEMNET, schools might run bi-annual ‘meet the engineer days’ for years 9 and 10 to enable all students to meet a diverse range of engineers and find out about the range of jobs and industries in which engineers work.
 - *Stakeholders: Employers, professional engineering institutions careers advisors and teachers*

Target: KS4 and KS5 BME school students and BME undergraduates

- Work placements and internship opportunities should be made more widely available for BME students both before and during engineering and technology study in higher education.
- More research is required into the different behaviour patterns of White and BME students in applying for and undertaking work placements and internships during undergraduate courses.
 - *Stakeholders: Employers, teachers, career advisors and HE staff*

Target: Girls aged 8-13

- The poster campaign, "Engineering, it's in everything" should be extended using a variety of images and different role models with the same strap line.
- Posters and role models are not enough. Each poster should be associated to a Challenge, such as ‘reverse engineer a cupcake’ thereby connecting engineers (most likely through the STEM Ambassador programme) to girls in years 5 to 8, i.e. aged 8-13.
- Stronger links between university ‘women in engineering and science’ groups and schools would be a help.
- Greater effort is needed to make the positive connection between engineering and girls to reinforce the message that there is a positive and common connection.
 - *Stakeholders: WES, WES members, professional engineering institutions, STEM Ambassadors*

Target: School students from BME backgrounds and from challenging schools

- Greater access should be provided to mentors from higher education, in particular students, and/or industry to talk about possible job roles, to provide feedback, and to challenge the students to achieve more.
- There should be more opportunities for pupils from challenging schools to attend summer camps which will inspiration and challenge.
 - *Stakeholders: Employers, HE course tutors and careers advisors*

Target: BME undergraduates

- Greater awareness is needed that in general male and female BME UK national students (and White female students) will demonstrate lower levels of confidence in their own technical abilities than their White male peers.
- More effort is required to ensure take up of internships, vacation jobs and year in industry placements by BME students which in turn will help them build their personal identities and confidence as engineers.
 - *Stakeholders: Employers, HE departments, HE staff and HE careers advisors*

Target: Women undergraduates

- There is a need to support networking and confidence boosting events for women (and BME) students and to ensure that all students are exposed to appropriate and relevant role models.
- Support should be available for a 'women in engineering and science' student group affiliated to the Women's Engineering Society to reduce the sense of isolation still felt by many.
- Support should be made available for students to attend national women in engineering / technology events or conferences.
 - *Stakeholders: Employers, HE departments, and HE staff*

About the authors

Sean McWhinnie established **Oxford Research and Policy** in 2009. Oxford Research and Policy is a consultancy that carries out research and evaluation and specialises in higher education, science policy, and equality and diversity. www.oxfordresearchandpolicy.co.uk

Katalytik was founded in 2004 by Jan Peters and specialises in evidence based policy development and implementation, making connections between education/ academia and industry. The key focus of the portfolio is inclusion and engagement in science and technology.

Jan Peters has had a vital involvement in many significant UK and international reports and projects related to women and science and engineering since 1999. www.katalytik.co.uk

The Women's Engineering

founded in 1919 to promote the study and practice of engineering and allied sciences among women. Today the Society connects women working in engineering and shares their excitement for how they are shaping the world and making a difference. Collectively the Society gives women a voice calling for equal pay, better career management and showcases talent for leadership.
www.wes.org.uk