GENDERS IN/OF ENGINEERING

A RESEARCH REPORT

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1 INTRODUCTION

1.1 Aims of the study

This study was prompted by evidence that professional engineering continues to be seen, and experienced, as somehow masculine. It addressed the premise that the retention and progression of women engineers is impaired not only because of well-rehearsed structural barriers (eg, lack of flexible work practices), but also because of subtle, 'taken-for-granted' gender dynamics. The central research question was: *(How) are the practices, cultures and identities of engineering more appealing to, comfortable for and supportive of (more) men engineers than women?* In sociological terms, the study sought to examine in detail various ways in which engineering may be 'gendered' and 'gendering' – ie, favours or creates certain masculinities and/or femininities. Gender is understood as a profoundly social phenomenon, pervasive 'in the social ether' and woven through our organisations and everyday interactions.

1.2 Methods

The design of this study differed from most previous research on the topic in two respects. First, the empirical focus of this study was not on women engineers *per se*, but on engineering as a *community of practice,* involving men as well as women. This was justified on the grounds that we will never understand fully the 'problem' of women in engineering if we don't understand better the men and masculinities of engineering. Accordingly, the research design sought, in the first instance, to collect data on the everyday practice of engineering and on 'what makes engineers tick' – and only then to bring a gender analysis to this material. Second, data was collected using ethnographic observation, through job shadowing, as well as interviews. This was essential precisely because so much of what this study sought to examine is 'taken for granted' and subtle – so would not be reported in interviews.

In total, 66 engineers (39 men, 27 women) were studied: 53 were interviewed (29 men, 24 women) and 26 job shadowed (16 men, 10 women). Field notes recorded far more than how the job was done. The observation took place in 5 workplaces: 1 software development department in the USA; 2 offices in a building design company in the UK; and 2 bases in an oilfield services company in the UK. In no sense was this fieldwork an evaluation of these companies. The point was to get a sense of the *variety* of different engineering work and workplaces. Those interviewed but not observed come from a range of disciplines and different sectors.

1.3 Acknowledgements

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1.4 The report

This summary report of the findings is presented in four sections, followed by a conclusion highlighting the main themes and recommendations arising:

- Becoming an engineer: The problem of retention
- The image problem: What makes engineers tick?
- 'Real' engineering: Technical *and* social
- Engineering workplace cultures: Men's spaces and in/visible women

2 BECOMING AN ENGINEER: THE PROBLEM OF RETENTION

2.1 Introduction

Opting to pursue a career in engineering is only the first step of *becoming* an engineer. It can take 10 years before entrants become 'fully fledged' engineers – including their university education and early years learning on the job. In the course of this lengthy and sometimes painful 'socialisation' process, many women and men are lost to the profession. This is therefore a critical period in terms of retention. I was interested in how this process of becoming an engineer may be gendered and gendering, and in any lessons as to how the losses of engineers might be stemmed.

2.2 Choosing

The most significant gender difference to emerge from the engineers I interviewed is not their reasons for choosing engineering (see 3.2), but *how they told me* about the choice. Engineering emerges as a more self-evident and 'gender authentic' option for men than for women. I have coined the term *gender in/authenticity* to capture the *normative pressures* of 'the way things are' – pressures which lead people to expect the gender norm (in this case, the man engineer) and to notice when they see something different (the woman engineer). Thus, there is nothing remarkable about a man choosing to be an engineer. Many of those interviewed provided little or no account of their choice; they either never gave it much thought or it was all pretty obvious to them. By contrast, virtually all the women interviewed *have a story to tell* about why they made the choice; like not having children as a woman, it demands an explanation. The reactions of outsiders are a constant reminder that being a woman engineer marks them out as unusual. And indeed, many if not most seem to relish this; they are extremely confident, high achievers, even rebels – the sort to seek out a challenge.

2.3 Education

In this context, it is striking that many women experience a rapid loss of confidence on entering engineering degrees. Many men and women students find engineering courses very difficult. Women students often assume everyone else is better than them, that they are not good enough. With time, most come to realise that *'We are all the same – good at some things and not others'*. And with time, many do very well academically. Socially, women engineering students often felt they *'stood out as a female'*, especially those entering before 1990. Of the more recent entrants, some reported no problem about being in a minority as a woman, but others were socially reticent, at least initially.

Part of the confidence problem may be that, on arriving at university, women engineers begin to experience the fall out of having made a career choice that counters the gender norm (see the 'in/visibility paradox': section 5). Another, widely acknowledged, issue is that hands-on practical skills are often presumed and fewer women than men engineering students arrive with them. Many men and women students struggle with the large mathematical content, the practical relevance of which is not always apparent in the way engineering is taught. Some universities are better than others in providing an integrated syllabus and high quality practical training.

The key benefit engineers feel they gain from their degrees is the thing they all see as the core of engineering expertise: a systematic, analytical approach to problem solving (alongside knowledge of relevant first principles). But inevitably, much of the expertise engineers need on the job is not provided through university education.

2.4 On-the-job learning

Most engineers report that it takes 4 to 7 years work experience before they feel they've really 'arrived' as an engineer (often marked by becoming chartered). Early days on the job can be bewildering; you realise *'you don't know jip'* and *'how little engineering there is'*. The more rounded engineering knowledge required – related to business processes, work relationships and the like – is built up slowly and iteratively. Fresh graduates are given discrete tasks working closely with someone else. As they gain experience of different types of work, they progressively understand more of the whole process and get given more responsibility. Along the way, there are a number of critical milestones, sometimes 'sink or swim moments': realising that you are mostly getting it right and that people are asking *you* questions, getting positive feedback from external partners or clients, and running a whole project from start to finish. Acquiring engineering expertise thus goes hand-in-hand with gaining confidence.

Women and men engineers alike struggle through these early years to some degree; both have to prove themselves. Nonetheless, there are some gender dynamics shaping how easily one gains membership (or not) in engineering communities.

The impact of individual managers, mentors and colleagues
There is variation between firms as to how formal the supervision and how structured the training. However, reports of good and bad experiences suggest that *individuals* have a far greater influence on easily junior engineers move up the learning curve: how supportive and approachable the individual supervisor, mentor, colleague or manager is during this period can have a huge bearing on whether young engineers stay (and how well they progress) in the profession. Many women and men have experienced a boss who did not trust their ability to do the job so never gave them the opportunity to prove they could. Some women engineers struggle with a hostile or unsupportive boss, because of resistance to women entrants.

Asking questions
Asking questions is a vital means by which (even experienced) engineers learn on the job. In practice, however, every new engineer discovers that there are some colleagues to whom you should not expose your ignorance (!) and others who are always happy to answer questions. It is often suggested that men are generally more reluctant to reveal their ignorance than women. Certainly, several senior woman engineers told me they always ask questions, in the spirit that *'There's no such thing as a stupid question.'*

Support networks and mutual support
Women entering the world of engineering work are typically in an even smaller minority, as women, than at university. Consequently, many discover that they particularly appreciate and benefit from the solidarity of other women engineers – either as immediate colleagues or through networks of women engineers. And throughout the early years on the job, women and men alike often seek out, and gain considerably from, solidarity with other junior engineers. (Ideally, of course, part of what all junior engineers need to learn is how to join the 'mainstream' networks that get the job done.)

Gaining credibility on the shop floor, on-site or offshore
Going on-site, offshore or onto the shop floor can be particularly nerve-wracking: junior engineers have to gain the respect of experienced workers who are/will be working for them. Here more than in the office, proving oneself often involves tests of gender as well as of job-related ability. Men and women alike can have to demonstrate they are 'one of the lads' (see section 5). In certain engineering sectors and workplaces, but not all, having good hands-on skills can be a major asset in the process of gaining credibility and membership. The main issue for women engineers, however, is the sheer numerical dominance of men since the non-professional grades in these setting are almost exclusively male: these really are 'men's spaces'

(cf section 5)! On the other hand, the somewhat protective attitude of many blue collar workers towards women engineers can mean they are given an easier ride than the men.

Career development and support

Some engineering faculty claim that proportionately more women than men engineering graduates are extroverts, and that for this reason they tend to do better in landing good jobs – since most employers are looking for personality as well as technical ability. In so much as people skills are also an important part of what new engineers must learn on the job, the extroverts will be somewhat advantaged at this stage. Once in employment, however, the men's careers often take off rather faster and further than the women's. In many cases, it seems, women (and probably men to) are lost for lack of strategic career advice and support at critical stages. Manufacturing may be particularly unsupportive of women engineers in this regard. Two women mechanical engineers, who both started their working lives in manufacturing and built up considerable expertise, found it impossible to sustain a career in this line of work. They have ended up in IT managing and teaching roles – feeling like they are no longer 'real engineers'.

In the course of learning engineering on the job, junior engineers are socialised into the company and the job as well as the occupation. They must pick up the company culture and business context; they must also learn to be (or behave as) particular kinds of people. And this often means they learn particular masculinities and femininities (see section 5).

2.5 Implications

In both engineering education and early years on the job, appropriate support and intervention can make a huge difference in the process of becoming an engineer – and, thus, in increasing the retention of young engineers in the profession. Much of what would be good for women engineers would also help men engineers. In this as in other areas, *quality* is vital to successful inclusion measures.

Engineering education

- Engineering faculty need to be enlisted in efforts to 'normalise' the woman engineer, amongst staff and students. They also need to be sensitised to the confidence loss some women engineering students feel on entering engineering education.
- The findings confirm that quality training in hands-on engineering is something women students generally need and benefit from. This is likely to benefit growing numbers of men too, as fewer come from a 'tinkering' background. More effort may also be needed to demonstrate the practical application of the core mathematical and theoretical teaching.

Early years learning on the job

- Training to support better mentoring and line management of junior engineers, and greater care in the selection of mentors and line managers.
- Encouraging a culture where 'there are no stupid questions'.
- Facilitating networking and mutual support for junior engineers, and women engineers.
- Providing ongoing support and advice over career development.

3 THE 'IMAGE PROBLEM': WHAT MAKES ENGINEERS TICK?

3.1 Introduction: The image problem – the technical/social dualism

It is widely perceived that engineering has an image problem, which makes it difficult to attract men as well as women into engineering. Arguably there is a particular image problem impairing attempts to recruit women, since the classic stereotype of an engineer is heavily gender marked – the man who is 'in love' with technology but rather socially withdrawn if not socially inept. This image draws on the conventional gendering of a dualism or dichotomy between 'the technical' realm and 'the social', by which men/masculinities are so readily associated (symbolically) with technology and women/femininities with people. The positing of these two sides as *mutually exclusive* – to be technical is to be not social and vice versa – is, I believe, a key reason why engineering is often perceived as a 'gender inauthentic' option for women. Thus, many efforts to recruit women into engineering (and computing) play up the 'social' content and play down the 'technical'. Yet, in seeking to get inside 'what makes engineers tick', this study reveals that *real engineers bear very little resemblance to the stereotypes of them*. There are numerous 'mismatches' between the image and actual engineers – mismatches which profoundly challenge the conventional gendering of the technical/social dualism, and indeed any presumption that women and men engineers are necessarily different.

3.2 What attracts women and men to engineering

Women and men have broadly similar drivers for choosing to embark on a career in engineering. Of necessity, they are all good at science and maths, and most positively enjoy these subjects – often because 'there's a right answer'. Virtually all say they want to do something practical. 'Practical' here can mean having good careers prospects, solving 'real' problems and, for some, making a difference: *'If you want to get something done then go and be an engineer!'*. Women engineers also get excited about technologies in the same way as men engineers. Rather few have a 'tinkerer' background, but a growing proportion of the men coming into engineering now have little or no hands-on experience also. Needless to say, liking maths and science is not necessarily mutually exclusive with others interests (art, literature) or with being 'social'.

3.3 Gendered 'styles' in engineering?

Women into engineering campaigners often claim that women bring a different approach to engineering. I sought to assess this claim by examining perceptions and practices around different 'styles' of engineering work. This revealed various differences – preferred modes of communication (email, telephone, face-to-face), hoarding or sharing knowledge, big picture or detailed focus, styles of writing and of inspecting computer code, etc. In the software development office, I then asked people if they saw any differences in how men and women colleagues did the job. Most reported emphatically no, but where the answers were affirmative, they were gendered along conventional lines. Most commonly, they told me that the women have better people skills and are more caring in their interactions with colleagues. A few told me that the men are *'more into tools'*, always wanting to play with the latest tool or the latest version of an existing one. And a few suggested that 'masculine' ways of operating and managing are needed to get on in the company.

In the event, my observations revealed only limited support for the claim that men engineers are more passionate about or fascinated by technology than women engineers, and no support whatsoever for the claim that women engineers have better people skills than their male colleagues. Because these claims are widely held, I elaborate below the evidence on each.

3.4 Pleasure in technology

Overall, engineers probably experience more highs in their work than people in many other occupations, even though they also experience common lows (work-life balance, corporate pressures, etc). Pleasure in technology is a major part of this, but this is not strongly gender differentiated if at all. Certainly, more men than women engineers are 'heavily in to' the kit and tools, but (given the relative numbers of men and women) this may not be disproportionate. Similarly, there are engineers who don't get terribly excited about the technology, and this group includes men as well as women. In short, the differences *amongst* women and *amongst* men engineers are greater on this score than any *between* women and men engineers.

Engineers involved in design or development work, women and men alike, typically feel a real thrill about something they've helped create – the completed building or telephone system – and are happiest when some part they've been slaving on works for the first time. Engineers in operational jobs get a thrill from working *with* particular technologies – either technologies which are especially sophisticated or, for some simply, 'big pieces of kit'. In both cases (creating or working with technology), there is a shared pride in, and identification with, the artefacts.

Engineers, women and men alike, also derive intense pride and pleasure from their expertise as engineers. Many relish the apparent *certainty* and *materiality* afforded by their reliance on 'the laws of nature' and on cause and effect reasoning: engineers build things that work. There is a sense of comfort even empowerment in this. And there is an obvious premium within engineering communities on having specialist expertise, and in knowing intimately a particular technology. Many engineers, therefore, seek out these pleasures repeatedly – the challenge of a difficult problem to solve, or something new to learn about.

Many engineers (perhaps proportionately more men than women) report that they enjoy working with engineers because they share the mindset and the thrills. In some very real sense, this makes engineering a 'separate reality' from the rest of the world: it is a sadness for many that outsiders, even loved ones, *'just don't understand'*.

3.4 People skills

Another mismatch between image and actual people emerged in relation to the widely held claim that women engineers have better people skills than their male colleagues. In all five workplaces where I conducted observation, I found no empirical support for this claim. There are two aspects to the evidence on this:

All engineers have reasonable people skills
With the possible exception of a few roles in research and development (R&D), all engineers *have* to interact with others, usually non-engineers as well as engineers. It simply isn't possible to do an engineering job without *some* ability to communicate and engage with others effectively! For this reason, the majority become more extrovert as they gain confidence and experience professionally. It is claimed that a significant proportion of engineers 'switch' from being introvert to extrovert (as measured on the Myers Briggs tests) in the course of their working lives. Moreover, the vast majority of those I saw take a care over how they handle social interactions and consciously work on improving their people skills. This includes handling conflict, difficult work relationships, collaborating with clients and contractors, team building and motivating staff, mentoring junior staff, working under pressure.

There is no general gender difference in people skills amongst engineers
It seems likely that even if more women engineering students than men are extrovert (as reported by some university staff), this gender difference rapidly disappears – precisely because people skills are such a vital part of engineering work. It is true that some men engineers seem to parade their lack of 'people skills', as if they are *performing* the stereotype – perhaps as a

shield for the naturally shy, or as a defence against the stereotype. But none of those I encountered are actually socially inept. Moreover, *counter examples* abound: I observed many men engineers who are supremely skilled on this front, and some women engineers who are socially reticent or awkward. Again, the differences *amongst* women and *amongst* men engineers, in terms of observed people skills, are greater than those *between* women and men engineers.

3.5 Engineer 'types' and the stereotype

To some degree, engineers tell me, the different engineering disciplines, sectors, roles and so forth attract different types of people. Detailed questioning revealed three main *types* of engineers – cutting across discipline and sector. Virtually all the interviewees identified the 'techies'. They are closest to the classic stereotype – very bright, very focused, but not always 'realistic' (eg, about the business context) and preferring to avoid social interaction, in some cases even 'borderline autistic'. Typically, I was told, these engineers work largely on their own in R&D jobs. The techies are distinguished from two other types, less obviously gender marked. One type of engineer has *organisational* and interpersonal strengths; they are likely to go into management or marketing roles. Another type is engineers whose key strength is *practical*, rather than theoretical. This group includes the (predominantly male) tinkerers who excel at hands-on skills and enjoy tools, but this is not essential. The defining aptitude of this type of engineer is that they come up with pragmatic solutions which *'get the job done'*, incorporating (amongst other things) the demands of the business context. The majority of engineers I interviewed, male and female, locate themselves in this category.

If we look at the women and men engineers studied *as whole people* we find a far greater diversity of types. This was investigated by drawing together (where possible) evidence on engineers' personal histories and out-of-work lives; and their character and personalities, including their comfort and/or expertise in emotional and social relationships. This reveals that some engineers conform to the stereotype, in so much as engineering provides a sense of being in control or powerful*,* which eludes them in other domains (personal, corporate). For some, too, the passion for technology extends into their out-of-work lives. As one might expect, however, *the vast majority of engineers are more diverse and more complex than stereotypes allow.* There is within engineering a wide range of 'types of people' – and, by this token, diverse masculinities and femininities. These often cut across conventional gender stereotypes. For example, many women engineers claim to be more comfortable with 'objectivity' than with 'subjectivity'; and there are 'gadget girls' as well as 'boys with no toys'.

The classic stereotype is simplistic if not well out of date. Yet, in spite of the diversity noted above, few engineers are neutral about the stereotype; indeed, many explicitly *position themselves* in relation to it – often with great irony. Some find the stereotype humiliating or disturbing and distance themselves from it, while others embrace it. A few challenge how the stereotype is interpreted, claiming that being an engineer makes them straightforward emotionally not reticent or socially inept. What we see here is that stereotypical images are operating, even when they do not map on to *actual* people.

3.6 Implications

The study amounts to a trenchant critique of the conventional gendering of the technical/social dualism: there are major mismatches between stereotypes and real engineers. It follows from this that efforts to tackle 'the image problem' surrounding engineering must avoid appealing to stereotypes, indeed must challenge them, if we are to 'normalise' engineering as a 'gender authentic' career choice for women. This is what American physicist Evelyn Fox Keller meant in her memorable call for us to *'count past two'*: we should eschew the 'ideology of difference' that says there just two types of gender, necessarily opposed in dualisms, and acknowledge the fact

that there are in practice *plural* masculinities and *plural* femininities. The need to count past two has become a recurring theme throughout this study.

Thus, the evidence presented in this section suggests that efforts to recruit women into engineering have a dual challenge. On the one hand, recruitment campaigns must 'speak to' the commonalities that would be men and women engineers tend to share – the passion for maths and science, the desire to do something practical, the excitement about technologies – rather than appealing to women in ways that presume they are necessarily attracted to engineering for different reasons from men. At the same time, recruitment efforts must also speak to the diversity of types and interests amongst would be engineers, especially if they are to reach those women (and men) who don't yet get excited about technology but could enjoy engineering. On both counts, we need to *make visible* and foreground the mismatches between stereotypes and real people – the counter-examples (the women who love technology or the men who are socially skilled), but also the lived diversity of engineers and of gender identities in engineering. The comment from a young woman graduate engineer, *'If you want to get something done then go and be an engineer!'*, would make a very positive – and non-gender marked – recruitment slogan.

4 'REAL' ENGINEERING: TECHNICAL *AND* SOCIAL

4.1 Introduction

One of the striking things about engineering is that the work extends far beyond the narrowly technical foundation provided by engineering education. In sociological terms, engineering practice is profoundly *heterogeneous*: it is simultaneously *both* social and technical. Even the most apparently technical engineering roles have social elements inextricably within them. Also striking is the huge *diversity* of work conducted by professional engineers – in the different disciplines, different roles (R&D, design, marketing, production, consulting, project management, senior management), different sectors and different types of companies. Together, these features create troubled identities in terms of engineers' sense (and presentations) of what constitutes 'real' engineering. The conventional gendering of the technical/social dualism surfaces again in these engineering identities.

4.2 Troubled engineering identities

Engineers have 'troubled identities' as engineers. On the one hand, engineers of all disciplines identify problem solving as the core of engineering expertise, and value the practical materiality and foundations in science which come with this. And indeed, it is these aspects which engineers, uniquely, bring when they collaborate with other groups (as in building design). On the other hand, as engineers rapidly discover when they start work, this core expertise constitutes only a small part of most engineering jobs. Engineers soon learn that all sorts of other, 'social' expertise is vital to their work – not least, the ability to work with others and to integrate business requirements into 'technical' decisions. Some engineers come to view these aspects as the more challenging and rewarding, so foreground a heterogeneous engineering identity. But many cleave to a *technicist*, 'nuts and bolts' identity – or oscillate uncomfortably between the two. And many engineering workplace cultures (see section 5) celebrate a 'nuts and bolts' identity, even though this is at odds with the actual work.

There are gender as well as professional dynamics at work here. The playing down of 'the social' and the celebration of 'the technical' in engineering identities converges with available masculinities in three ways. First, as noted in 3 above, the apparent certainty and materiality provided by engineering expertise can feel very powerful, which resonates with the trope of 'mastery' in all versions of *hegemonic* masculinity (the standards to which men are supposed to aspire). Second, technology is strongly masculine coded. The power of built technologies is frequently associated culturally with men and masculinity in industrial cultures. And the 'nuts and bolts' version of engineering invokes hands-on work with technology – an area in which even now women are virtually absent and which has connotations of blue collar 'muscular masculinity'. Third, within the stereotypical gendering of the technical/social dualism, identifying with 'the technical' means distancing oneself from, or at least playing down, 'the social'.

These gender dynamics can mean that those men engineers whose masculinity is closely tied up with technology are reluctant to move into managerial roles or experience troubled identities if they do so. Even though these are powerful roles attracting high status and money, and even though senior management roles are also very 'gender authentic' for men, they do not feel like 'real' work in the way that engineering does. There is also, for some, a fear of losing membership as 'one of the lads' by losing touch of 'the nuts and bolts' – a recurring theme in humour between men engineers and their managers. Yet, all of the engineering managers I observed still use technical expertise – as a sociologist, I could not do their job!

It may be significant that the gender marking of management is somewhat ambivalent: management is associated with 'soft' people skills as well as 'hard' commercial reality. Perhaps for this reason, women engineers seem to move more easily into project management than into

senior management roles. Tellingly, women engineers who move into management at all are in greater risk of losing their (perceived and felt) engineering identity than men who make the same move – because their gender identity is not allied to being technical in the way it is for men, and because the 'gender authenticity' issue never quite goes away for women in a heavily male-dominated occupation. One very talented woman engineer I studied left her design engineering company for a project management company, in part because the former encourages a 'nuts and bolts' culture.

It seems likely that, so long as engineers and their profession celebrate a narrowly technicist identity, and so long as that identity remains closely tied up with available masculinities, women's membership as 'real' engineers will continue to be more fragile than men's.

4.3 Implications

In effect, this strand of the study amounts to a further rebuttal of the conventional gendering of the technical/social dualism: the dualism does not map onto engineering practices any more than it maps onto engineers as people. What we again see here is that the technical/social dualism *performs gender* (does gender work) symbolically. It makes it easier for men to identify with the 'nuts and bolts' of engineering, even though this is at odds with actual engineering practices. And it casts people skills as 'soft', for women, even though this is at odds with actual engineers.

An important conclusion flows from these findings: *engineering as a profession must find ways to foreground and celebrate a 'broad church' image, one which reflects the heterogeneous and diverse reality of engineering work*. There are two compelling reasons for this conclusion. First, that is what engineering is! Engineering encompasses a wide variety of jobs, in which the relative weight of technical and social elements (amongst others) varies along a spectrum. Second, within this 'broad church', there is room – indeed a need – for a wide variety of 'types of people', according to their particular skills and personality. If the profession does not promote an identity for itself which welcomes this diversity, then it will fail to attract some valuable and much needed talent. And if the profession nurtures a 'mono-culture', in which only people from one spot on the technical/social spectrum really feel they belong, then it will lose some valuable and much needed talent.

Promoting a more heterogeneous and diverse image of engineering can only serve to make the profession more inclusive (of all). If such moves are to be more *gender* inclusive, however, then they must also challenge the conventional gendering of 'the social' and 'the technical'. In this context, 'counting past two' means challenging not only the dualisms which cast women and men as necessarily different, but also those which cast engineering as necessarily technical *or* social (but not both).

5 ENGINEERING WORKPLACE CULTURES: MEN'S SPACES AND IN/VISIBLE WOMEN

5.1 Introduction

There are several well understood and well documented reasons why men engineers tend to do better than their female colleagues in terms of career progression: the disruption caused by career breaks for having children and the lack of support for returners; failure to tackle long hours and work-life balance issues; pockets of male hostility. Important though all these issues are, several more subtle factors can also have a significant impact on how much women engineers are seen as belonging – and thus on whether they stay and get on. Membership in the workplace culture is one of these.

It is frequently claimed that women who enter engineering have to 'fit in' to 'a masculine culture'. To date, the evidence for this has been mostly anecdotal; for the first time, this study provides systematic evidence – on the basis of the observational fieldwork conducted. This aspect of the study addresses the questions: *Are engineering workplace cultures more comfortable to (more) men than women engineers? And is it easier for men to 'belong' in these cultures?*

I am using the term *workplace cultures* to capture a rather amorphous collection of practices, which characterise everyday interactions amongst engineers as I observed and heard them: styles of interaction, topics of conversation, humour, social circles. Workplace cultures serve two important social functions: (i) they oil the wheels of the job and the organisation; and (ii) they have the potential to shape how much people 'belong' at work – and so who stays and progresses within a company or occupation. Crucially, both the work and people's out-of-work lives and identities are interwoven in workplace cultures, which means that engineers are often 'doing gender' as part of 'doing the job'.

The five engineering workplaces I studied differ markedly, although there are positive and negative practices in each. The overall picture is mixed. There are many *gender inclusive dynamics*: respectful styles of interaction, wide ranging and inclusive topics of chat and humour, genuine affection towards female colleagues, considerable mixed-sex socialising and camaraderie, changing attitudes of older male engineers. However, there are also many *gender exclusive dynamics*. Individually, these may appear minor, even trivial. Taken together, however, they have a 'dripping tap' effect over time. They make engineering workplaces feel and operate like a fraternity – or 'men's spaces' – in which it is harder for women engineers than men to 'belong' and get on. This is exacerbated by what I have termed an 'in/visibility paradox', which women and not men engineers face routinely in engineering workplace cultures (and beyond).

5.2 Men's spaces

Subtle absences: signals of bonding are fraternal

Routine ways of greeting one another, and of signalling solidarity or familiarity, which men use with other men – e.g., the use of 'mate' or 'man', even the handshake – are absent when men interact with women engineers. These subtle absences may be especially significant, for women engineers, as they build relationships with new male colleagues, collaborators or clients. There is a greater formality when men engineers interact with a woman associate they do not yet know than with a man, which suggests that women engineers may have to work harder to achieve the same level of easy acceptance with new associates that men achieve.

The generic 'he' when referring to engineers

The virtually universal use of the 'generic he' when referring to other engineers is not trivial. At best, collective references like *'We put our key men forward'* or *'Go talk to the electrical boys'* render women engineers invisible; at worst, they render the very category 'woman engineer' a non-sequitur – a worrying subliminal message.

Non-work topics of conversations reflect conventional masculine interests
Whilst non-work chat between close colleagues is fairly wide ranging and inclusive, the less routine conversations with *outside associates* tend to lean more readily on gender-stereotypical subjects as 'safe' common meeting points – most commonly football, cars and families. The more narrow the range of conversation, the more men and women are marginalised or silenced.

Offensive humour and sex talk is tolerated
Many engineers take a care to avoid potentially offensive jokes and topics of conversation. However, the humour in some workplaces is very coarse and offensive – including, sexist, racist and homophobic jokes as well as 'dirty talk'. Whilst many men and women find this uncomfortable, any challenges are muted because opposition risks loosing membership of the community.

Men's circles and networks which are organizationally powerful
Men-only social circles are common in engineering. Some but not all are organizationally powerful, in terms of how the job gets done and who gets promoted. Breaking into these 'inner circles' can be difficult for women (and marginal men) – not least because they bond through shared interests, humour, etc. at the golf course or over drinking sessions.

A larger range of masculinities than femininities is available
Engineering workplace cultures accommodate a range of masculinities – laddish blokes, family men, pranksters, macho men, nerdy men, urbane men, genteel men – and so are likely to feel comfortable to the great majority of men. By contrast, women engineers often face pressures to either play up or play down conventional femininity (see 5.3 below). Also, by sheer dint of numbers, far fewer 'alpha females' than 'alpha males' are available as role models in any one workplace.

Heterosexual norms operating
There are clear heteronormative pressures in engineering workplace cultures, in so much as no-one in the UK workplaces I observed is openly gay, families are a 'safe' topic of conversation, and homophobic jokes are tolerated. For the same reason, women engineers are *sexually* visible in ways which their male colleagues rarely have to handle (see 5.3 below).

5.3 The 'in/visibility paradox'

This study confirms prior research findings, that women engineers are so visible as women that they are often *in*visible as engineers. Consequently, even really experienced women engineers can have to (re)establish their engineering credentials every tie they encounter a new colleague or associate. This represents *an extra layer of work* that women, and not men, engineers must do in order to be seen to 'belong' in engineering.

This is part of an 'in/visibility paradox' by which *women engineers are simultaneously visible and invisible*. Another part of this paradox is that, in spite of being visible as women, women engineers are expected to adapt and become 'one of the lads in order to 'fit in' to the majority culture, the men's spaces. At the same time, they face pressures not to 'lose their femininity', not to behave like men in certain areas.

Part of the issue here is that being visible as a woman means being (hetero)sexually visible. Men engineering students are reported to view women on their course as *either* ugly and lesbians *or* pretty and out to find a man. And most women engineers – *but not men engineers* – have experienced sexual harassment and/or heavy flirting from male colleagues or associates at some point. Often young women are unaware of procedures in place to respond to harassment.

5.4 Implications

Improve relative numbers of women in engineering

In so much as workplace cultures are shaped by the majority group, then a crucial part of any strategy to make engineering workplace cultures more comfortable for women engineers is to sustain efforts to *directly increase* the proportion of women in engineering. The numbers issue extends to other groups. For example, where professional engineers work with operator and technician grade engineers who are all men, the 'dilution factor' facing women is enormous. Arguably, the gender dynamics in such workplaces are unlikely to improve much unless the proportion of women in apprentice-entry roles is also increased dramatically.

Raise awareness

Tackling the numbers will not *on its own* solve the problem, however, since most engineers, male and female alike, are unaware of the more subtle gender dynamics revealed by this study. Awareness is a key issue. Some companies have made a real impact on their staff – eg, on what jokes are acceptable – through sustained and sensitive diversity training. This can work to nurture more inclusive ways of interacting with colleagues and associates, to create a culture where everyone is comfortable and 'belongs'. An important aim is to encourage men engineers to become agents of such culture change, rather than leaving it to individual women engineers to fight battles which leave them even more isolated than they already are. This means that, to be effective, diversity training needs to be targeted on all staff, and it needs to be tailored to the particular workforce. But clearly there are many challenges – not least, how does one do diversity training effectively, without alienating the majority group and creating a backlash?

Establish and promote 'top down' support for diversity policies

There is a strong business case for such measures if the industry is to retain more of the women engineers they recruit (and quite possibly more of the men). Diversity policies need to have a strong and visible endorsement from senior management, and win the backing of middle managers, if they are to be effective. In addition, top down policies can take the pressure off individual women and men to fight offensive cultures: eg, the banning of pornography, explicit support for tackling racism or sexism. In many workplaces, more also needs to be done to increase awareness that sexual harassment and any kind of bullying is unacceptable, and of the procedures in place for handling this.

6 CONCLUSIONS

6.1 Analysis

Three cross cutting themes emerge from the analysis of this research.

Gender in/authenticity
I have coined the term *gender in/authenticity* to signal the non-congruence of gender and engineering identities for women, and the congruence of these identities for men. The key analytical point is that the (perceived and felt) 'gender inauthenticity' of the woman engineer is *consequential*. It does not end when women make their choice to become an engineer; it means they face ongoing in/visibility issues which men engineers never experience – having routinely to (re)establish their engineering credentials, and being gender/sexually visible. The term 'gender in/authenticity' should not be taken to imply that 'the way things are' can or should never change, however. Quite the contrary: the finding that women and men engineers are motivated by broadly the same drivers clearly challenges the *presumed* non-congruence of gender and engineering identities for women – so represents an important step towards normalising the woman engineer.

Belonging in engineering
Belonging (or not) in engineering communities occurs through (amongst other things) the common socialisation into particular ways of doing engineering, the shared identities and pleasures in engineering, and membership in engineering workplace cultures. We have seen that belonging in engineering is gendered/ing in various ways. The masculine coding of engineering work is evident in the presumption of hands-on skills, in stereotypes of the engineer, and in the celebration of technicist engineering identities. Through numerous gender dynamics, engineering workplace cultures function, to varying degrees, as men's spaces which women engineers (and some men) have to 'fit in' to or remain on the margins of.

The technical-social dualism
The conventional gendering of *the technical-social dualism* simply cannot be ignored if we are to understand the continued male-dominance of engineering and come up with better ways of improving the representation of women in engineering. The need to 'count past two' applies in relation to both gender and engineering: in particular, the need to challenge the all to easy association of men/masculinity with things technical and women/femininity with things social. One obvious way to achieve this is to highlight mismatches between images of engineering and actual people and practices – not least, the technology-loving women and the socially skilled men.

6.2 Recommendations

The main recommendations indicated by these findings are:

1 Sustain efforts to **directly increase the proportion of women** in engineering. Tackling the numbers issue is an essential adjunct to efforts to effect any 'culture change'.

2 **Avoid appealing to gender stereotypes** in recruitment campaigns. These should 'speak to' the enthusiasm about maths, science and practical technology which would be men and women engineers share. And at the same time, they should make visible the range of masculinities and femininities amongst actual engineers.

3 **Foreground and celebrate a 'broad church' image of engineering**, with room for diverse 'types' of people. We must avoid narrowly technicist images of engineering work if we are to attract, and keep, talented people in engineering – by promoting images of engineering work as *both* technical and social.

4 Strive to **'normalise' engineering as a career choice for women** – in relation to retention as well as recruitment – through campaigns both within and outwith the profession.

5 Sustain and promote **good practice in engineering education**. This includes attention to hands-on training and the integration of theoretical and practical elements in engineering degrees.

6 Sustain and promote **good practice in the support of junior engineers at work**. This includes attention to mentoring, line management and career development, plus encouraging mutual support through peer and women's networks.

7 **Increase awareness of the gender norm and in/visibility issues** facing women engineers – amongst engineering educators, in engineering workplaces and in the professional at large.

8 **Nurture more inclusive workplace cultures**. There is a strong business case for sensitive and sustained efforts to increase gender and diversity awareness amongst engineers – backed up by visible 'top down' support for diversity policies.