Chapter 2
'Nuts and Bolts and People' Gender Troubled Engineering Identities

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Abstract How and where boundaries are drawn between 'the technical' and 'the social' in engineering identities and practices is a central concern for feminist technology studies, given the strong marking of sociality as feminine and technology as masculine. I explore these themes, drawing on ethnographic observations of building design engineering. This is a profoundly heterogeneous and networked engineering practice, which entails troubled boundaries and identities for the individuals involved – evident in interactions between engineers and architects, and amongst engineers, around management and design. There are complex gender tensions, as well as professional tensions, at work here. I conclude that engineers cleave to technicist engineering identities in part because they converge with (and perform) available masculinities, and that women's (perceived and felt) membership as 'real' engineers is likely to be more fragile than men's. Improving the representation of women in engineering requires foregrounding and celebrating heterogeneity in genders as well as engineering.

Keywords Engineer identities • Heterogeneity • Technical/social dualism • Gender

Introduction

In conversation with a friend who has been an engineer for some 40 years, I discovered he had worked in quite different sectors and technologies, from toy manufacturing to road bridge maintenance. He explained, 'It's all engineering really – all nuts and bolts.' Then he paused for a minute and added, as if to correct himself, 'Well, nuts and bolts and people'.

Engineers have two types of stories about what constitutes 'real' engineering: in sociological terms, one is *technicist*, the other *heterogeneous*. For instance, engineers commonly report that their biggest surprise when they started their first

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engineering job after graduating was how little time is spent on 'real' engineering, by which they typically mean 'calculations and drawings'. The emphasis on calculations is hardly surprising. The core of university-based engineering education is a mathematical approach to analytical problem solving in which problems are 'reduced' to their physical properties and social complexity is pared away (Bucciarelli 1994, p. 108). This training stands in stark contrast to the huge importance of 'social' expertise in engineering jobs, which engineers soon learn is actually vital to their work. Some, like my friend, come to view these aspects of the job as the more challenging and rewarding; others cleave to a 'nuts and bolts' identity. But virtually all the engineers I have met oscillate between or straddle, not always comfortably, technicist and heterogeneous engineering identities.

Social studies of engineering problematize the deep technical/social dualism at the heart of engineering identities and practice. As numerous case studies have demonstrated, the knowledge mobilised in engineering practice is never 'just technical' with 'the social' bolted on (e.g. Bucciarelli 1994; Downey 1998; Vinck 2003). Rather, these two dimensions are in a very practical sense *inseparable* – hence the unhyphenated term 'sociotechnical' (Hughes 1986) – and the boundaries drawn between them are inevitably arbitrary. As Downey and Lucena conclude, engineers live 'on the constructed social boundaries between science and society and between labor and capital' (1995, p. 167). But is this the full story? In this chapter, I seek to 'write gender in' to these accounts.[1] How and where boundaries are drawn between 'the technical' and 'the social' in engineering identities and practices is a central concern for feminist technology studies, given the strong marking of sociality as feminine and technology as masculine, and the continued numerical dominance of men in engineering in most disciplines and most Western countries (Faulkner 2000b). Yet the connection is rarely made in the otherwise interesting literature on engineering identities.

This chapter seeks to redress this gap. It draws on ethnographic fieldwork in two UK offices of a building design engineering consultancy company. This involved job shadowing six engineers over the course of 5 weeks, two of whom – Karen and Fraser – I followed for over a week each, offering many opportunities for extended conversation. During this fieldwork, I was able to observe closely the routine office-based practices of some 20 engineers, plus several meetings with external partners.

The design of buildings is a networked and staged process involving a heterogeneous array of partners – engineers (various disciplines), architects, clients, cost consultants, building contractors, suppliers – each of which is vital but none of which could do the job on their own. Because of the complexity and scale of any major building, and the diverse expertise required, control is a major pre-occupation and relations can become very political. The engineering expertise required in building design is itself heterogeneous. Much of it is specific and can only be built up on the job: an appreciation of particular client/user requirements; knowledge of relevant products, regulations, etc; networks of contacts; and above all, a cumulative body of

[1] Other intersections of identities have been addressed, including intersections of national identities and engineering identities: e.g., Meiksins and Smith (1996), Downey and Lucena (1997 and 2004).

experience of 'what works and what doesn't'. In addition, building design engineering demands considerable people skills – precisely because the design process necessitates sophisticated management and 'conversations' between the diverse partners.

The body of this chapter examines some of the troubled engineering identities and *boundary work* which flow from this heterogeneity.[2] It looks at boundaries between engineers and architects, and at boundaries amongst engineers around design and management. In both cases, the troubled identities reflect very real and rather intractable professional and organizational dynamics; but they also reflect very real and rather complex gender dynamics. These dynamics help explain both the persistence of technicist engineering identities and the tensions between these and heterogeneous ones. First, I open with some background on the framing of the study and on how I understand gender.

Genders in/of Engineering

The fieldwork presented here was part of a larger study, 'Genders in/of Engineering', which sought to examine gender dynamics within engineering practices, cultures and identities.[3] The study was posited on the conviction that we need to know more about the men and masculinities in engineering if we are to understand better the continuing poor representation of women in engineering. By using ethnographic methods, it addressed the premise that the retention and progression of women engineers is impaired not only because of well-rehearsed structural barriers (e.g., lack of flexible work practices), but also because of more 'taken-for-granted' gender dynamics not always evident to participants. In particular, the study has identified a number of subtle dynamics by which people come to *belong* (or not) in engineering communities of practice (e.g. Faulkner 2009a).

In line with much feminist technology studies, I understand gender and engineering as co-constructed or *co-produced*.[4] This often operates symbolically. Thus, the technical/social dualism does not necessarily map on to actual people and practices – which are typically diverse – yet it performs gender work. For instance, the 'nerd' stereotype is of men who are passionate about technology but rather a-social. The fact that these two poles of the dualism are posited as mutually exclusive – to be technical is to be not-social – is one of the ways in which engineering appears 'gender inauthentic'[5] for women, given the strong association of women/femininities

[2] Gieryn's (1995) concept of *boundary work* has been helpful in illuminating the constructed nature of boundaries around many areas of science or technology. The key analytical point is that how and where boundaries are drawn at any one time and place is often consequential.

[3] Faulkner (2000a) indicates the framing of this larger study. In total 66 engineers were interviewed and/or observed; where not attributed, later claims are derived from this wider fieldwork.

[4] This framework has been elaborated and reflected on in: Lerman et al. 1997; Lohan 2000; Wajcman 2000; and Faulkner 2001.

[5] The concept of 'gender in/authenticity' is elaborated in Faulkner 2009b.

with caring about people. I take it as one of the valuable contributions of well grounded social scientific research that it can reveal the extent of mismatches between such stereotypes and actual people or practices, and so serve to destabilize stereotyped assumptions. For example, my fieldwork revealed no evidence to support the common assumption that women engineers have better people skills than men engineers, which is an important but largely un-trumpeted challenge to the 'to be technical is to be not-social' stereotype of engineers.

I have coined the term *gender in/authenticity* to capture the normative pressures of 'the way things are' – pressures that lead people to expect the gender norm (in this case, the man engineer) and to notice when they see an exception (the woman engineer). There is nothing remarkable about a man choosing to be an engineer, while the reactions of outsiders are a constant reminder that being a woman engineer marks them out as unusual. I must stress that I use the term gender in/authenticity in a non-essentializing way. The term is not meant to imply that 'the way things are' can never change: far from it. Much of the evidence in the larger study profoundly challenges the presumed non-congruence of gender and engineering identities for women. The point is that gender in/authenticity issues are consequential; they *perform gender work*. Thus, the perceived gender inauthenticity of the woman engineer means that women engineers face in/visibility problems (cf Tonso 2007) which men engineers never experience: they tend to be highly visible as women but not as engineers, so have routinely to (re)establish their engineering credentials (Faulkner 2009b).

Troubled Boundaries Between Engineers and Architects

Without exception, the building design engineers I met distinguish the professional orientation and interests of engineers and architects around a dualized boundary: architects want a building that 'looks good', while engineers want a building that 'works'. The distinction drawn – between 'design' and technology – is misleading. In practice, there is considerable overlap between the two communities in terms of what they actually do and know. There has to be. The form of the building has to accommodate all its functions, including the building services of power and water supply, air quality, etc. So, building design engineers and architects acquire what Harry Collins and Rob Evans (2002) call *interactive expertise* in each other's specialisms in order to collaborate effectively. They also share important subjectivities: they both derive huge pride and satisfaction on seeing the finished building, and enjoy talking about other publicly visible buildings.

Mechanical engineer Karen illustrates many of these points. Unusually, her degree combined architecture and engineering. She describes architecture as being 'more design than sums' and says she might have become an architect but 'I felt more of an engineer. I was a bit too practical for architecture … I need more to justify a space than "it's the right aesthetic" – it has to fulfil its function, it has to make people comfortable, it has to use the appropriate amount of energy, etc.' Karen has a particular interest in low energy and sustainable building design. She asserted

her belief that 'we engineers understand more about it than architects' with some humour at a meeting to prepare a bid to design sustainable offices. The engineers and architects present chat about the 'green' gherkin-shaped building in London. Karen asks 'Is there any assessment of the Atrium and how it will work? [since] *air doesn't do that!*'. Eilidh, the other engineer present, explains that the architects behind this building 'love arrows: blue one for cold air and red ones for hot … *They think they can change the laws of physics!*'. Karen joins in, lamenting the marketing of 'stupid ideas that don't work'. Perhaps sensing that the architects present don't really understand the problem with arrows, she then explains, grinning, "They behave as if you can make air do what you want it to do! [But] cold air pushes hot air up. Hot air doesn't rise – *it's a myth!* It's displaced by cold air, which is denser and needed to drive it. In a room full of hot air there is no air movement." She laughs openly because, like many engineers, she identifies strongly with the apparent certainty which flows from their reliance on science; she relishes the fact that such expertise distinguishes her from non-engineers.[6]

The technicist professional identity Karen is expressing here is associated both with science and with a kind of practical materiality – something I encountered repeatedly amongst men and women engineers. Engineers' educational grounding in mathematics and science enables them to claim an identity in the material and (mostly) predictable phenomena governed by 'laws of nature', backed up by a faith in cause and effect reasoning (see also Mellström 1995). And this same materiality and scientificity enables them to claim, as the central contribution of engineering design, that it creates technologies that 'do the job'.[7] This is a very empowering identity, in the very literal sense that buildings are empowering: they enable users to do things. This is why engineers in all sectors celebrate the visible outcomes of their work (Florman 1976; Hacker 1989, 1990). And it is why engineers' practical and scientific expertise *feels* empowering to them, when contrasted with a lack of such expertise in others.

The certainty and materiality associated with science and technology can also be very powerful *symbolically* – with significant gender connotations, at least historically. As feminist scholars have demonstrated (e.g. Merchant 1980; Noble 1991), achieving control and domination over nature was a central plank in the Baconian project – and a central justification, at the time, for excluding women from that project. Similarly, Ruth Oldenziel (1999) has demonstrated that the strong association of engineering with industrial technology (machines), with science and with corporate might, served to code engineering as heavily masculine during the period of its professionalization. In short, the establishment of both science and engineering involved the emergence of new versions of what Bob Connell terms *hegemonic masculinity* (1987, 1995). The 'mastery of nature' remains a powerful emblem of

[6] Humour ridiculing the lack of 'technical' knowledge amongst others is a common feature of engineering communities (Hacker 1990, Chap. 4; Mellström 1995, Chap. 5).

[7] I am not suggesting that engineering guarantees certainty. The point is that engineers see their role as seeking to reduce uncertainty to acceptable levels, and that the palpable successes of modern technologies in achieving this gives them comfort (Kleif and Faulkner 2003).

technology, both within engineering (e.g. Florman 1976, pp. 121–26) and in wider culture (e.g. Caputi 1988).

Elsewhere I have suggested that engineers' shared pride and pleasure in the technologies they build can be read as a vicarious identification with the power of technologies, perhaps even a kind of *symbolic compensation* for a felt lack of power in other aspects of their lives (Faulkner 2000a). It has been suggested that this might explain the particular appeal of engineering to men – to the degree that performances of masculinity 'demand' a sense of mastery over something (Edwards 1996), and that men 'have a problem' with interpersonal relationships (Hacker 1990, Chap. 4). Tine Kleif and I (2003) found this hypothesis to hold for some men but by no means all. Many women engineers I have encountered also like science and maths 'because there's always a right answer', and many also get excited by 'big bits of kit!'. The fact that the theme of power resonates with hegemonic versions of masculinity does not prevent women engineers from enjoying the felt power of built technologies as much as men.

To recap The need for 'conversations' between specialists in a networked design process creates contradictory impulses about what counts as 'real' engineering. On the one hand, all the partners have to be able to 'meet in the middle' in order to collaborate. On the other hand, engineers have an occupational interest in foregrounding the 'core' scientific and technical expertise which only they, as engineers, can bring to the design process. I have suggested that there are other subjective dynamics at play here too – engineering identities strongly tied up with the actual and felt power of built technologies, and with the apparently certainty afforded by their use of mathematics and science. Whilst these subjectivities are strongly associated historically and symbolically with available masculinities, they are no longer confined to men.

Boundary Spanning

In practice, some engineers are more proactive than others in their relations with architects. Karen enjoys working at the interface between engineering and architecture, and says her job 'is as much about people and relationships as sizing stuff'. In the same spirit, Karen is often animated about 'the people aspect' of building services engineering, including the very real difficulties associated with engaging the end user in making the building 'work'. As she commented during the preparation of the sustainable office bid:

> They [the client] need to think about the control system. Sustainability ends when you put people in! You need to train staff to ensure that the building is operating correctly. We mustn't leave once it's built. … If you don't get buy in, the buildings won't operate properly, and it will overheat. You probably need some automatic features [but] if it's all automatic, they'll also complain. You need people to like being there. …. For example, you can introduce digital displays in the building about water and energy use – so people know. It increases awareness and ownership. … It's all about people: designing buildings people can use!

Eilidh also works at the engineering-architecture boundary. Later in the meeting, when Karen has been running through some of the requirements for water use and heating, she says to the architects present, 'It's useful to have this discussion in front of [the client] to show we know the subject, to show we're not soft engineers who can't deliver!' Both women make frequent use of the hard/soft dualism. Eilidh comments on the landscape architect's concept of a 'pavilion': 'It can sound very soft and not very commercial'. There is a clear value hierarchy in these quotes: hard is associated with being effective commercially, with the 'nuts and bolts' of engineering and with 'being able to deliver'; soft is associated with 'aesthetics', with the people aspects of design and, perhaps, with idealism in relation to sustainability. The symbolic gendering of this 'hard-soft' dualism is fairly self-evident (see Faulkner 2000b). What I want to emphasize here is how Eilidh and Karen are building a space in which the importance of *both* 'hard' and 'soft' issues – and the need for *both* 'hard' and 'soft' expertise – is acknowledged.

Troubled Boundaries Amongst Engineers

The identity work performed by engineers is wrought with tensions and contradictions. Karen is clearly a 'nuts and bolts and people' type of engineer. Yet she sees maths, science and practical technology as central to her engineering identity. As noted earlier, the mathematical competence so emphasized in engineering education is often all but absent in engineering practices. I was treated to many playful asides about this – like, 'See, I did some sums there!' and, after 2 days of shadowing, 'This is the first calculation you've seen me do!'. I feel such jokes indicate a realistic irony, even wistfulness, about the inadequacy of the technicist version of engineering. They serve simultaneously to challenge and reproduce an image of engineering that is at odds with the actual work. The loss of a technicist identity is a readily recognized lament.

These tensions beg several questions: What do individual engineers feel about the mismatch between the actual heterogeneity of their work and the technicist focus of their education? How do they position themselves in relation to the (implied) technical-social scale? And what are the implications of different positionings in terms of 'getting the job done', career progression and perceived membership as 'real' engineers? The cases Karen and Fraser provide interesting insights.

Karen

Karen's joint degree has not held back her career as an engineer. Five years after graduating, she was responsible for the design of the mechanical building services in a major iconic building, incorporating many principles of sustainability. She subsequently won a prestigious national prize for this work, became chartered and was

promoted to a level where she could bring in new business, undertake concept design and run projects unaided. Like many others, however, she feels some ambivalence about leaving behind the more 'back room' work of detailed design:

> There are weeks when I feel I've done no engineering at all. The person I am now is a project manager/design manager. … Every now and then I get a craving to do some sums. It used to bother me more. The feeling of 'not producing anything' has made me unhappy at times.

Karen juxtaposes the 'up front' and 'backroom' roles in a way that echoes the technical/social dualism. She has a sense that her new roles are less 'real' engineering, perhaps because they are further away from the materiality of 'producing' things. Nonetheless, having established her engineering credentials, she now feels she has earned the right to concentrate on the more up front work, which she feels her personality is suited to. She believes people should be allowed to concentrate on the jobs where their strengths and interests lie. Unfortunately for Karen, this view is not shared by her manager, Tom, although he esteems her highly:

> Tom used the term 'captain and cabin boy' when I joined – i.e., we all have to do a bit of everything, from basic stuff through to management stuff. … Problem is, I don't really want to be the cabin boy anymore – again been there, done that – and I've worked very hard to progress to a point where I don't have to do that role anymore. … I'm more than happy to do the concept design and get things kicked off and then run the job, but the thought of spending the next several years tied to my desk detailing and personally putting tender packages together fills me with dread. … I definitely see my future as a project/design manager and not sure that I can do this within [the company].

Five months later, Karen left the company in which she has had such a brilliant early career, for a job in project management – a move which, though still in mechanical building services, she sees as leaving engineering.

It would be wrong to view Karen's story as a tragedy. For Karen, this will probably prove a good career move, and her obvious talent is not being lost to the design of new buildings. What her story does illustrate, however, is how perceptions of what counts as 'real' engineering can have a material bearing on who is and is not deemed to *belong* in engineering – and thus, on who gets to stay and progress. In part, as Karen rightly perceived, she did not 'fit' because the business model of the regional office where she now works (the captain and cabin boy) differed from that in the head office she previously worked (where post-chartered engineers are *expected* to move into managerial roles and detailed design is conducted almost exclusively by junior engineers). In part, however, I suspect that Karen's fragile membership in the regional office was also due to the culture and ethic of her colleagues, many of whom appear to celebrate a 'practical', 'nuts and bolts' version of engineering. There were gasps of astonishment once when Karen admitted that she'd never 'sized' a gas pipe – *'You've got this far and never sized a gas pipe?!'*.[8]

[8] Sizing here refers to the calculation needed to establish what diameter of pipe is needed for a particular purpose. Karen asked how to size a gas pipe because, as it happens, she'd never had to do it for gas before. She acknowledged their astonishment in her reply: 'I know, but how do you do it?'.

In this setting, it seems likely that some of Karen's colleagues were unimpressed by her disdain for practical and backroom jobs.

Fraser

Fraser is more in line with the culture and ethic of the regional office. Like Karen, he works in mechanical engineering building services and is in his early 30s. He also has a demonstrated talent for management and up front roles. He is currently project managing the company's design of building services for a major office development. This means he plays a pivotal role between the dozen or so company engineers doing the detailed design and the wider network of partners in the project. It is the first time Fraser has done so much 'people management' and financial control. In his own time, he has developed a detailed plan for the design process – breaking down the jobs into tasks, with milestones and estimates of the number of drawings required for each. From this he worked up a spreadsheet of the hours per month needed from everyone on the job. These two documents are bound together with selected drawings marked up to show areas of flexibility. The whole document is half an inch thick. Fraser gave copies to all staff on the project, 'so they own it and know where their work fits in and have personal targets'.

This very heterogeneous reality of Fraser's work does not sit entirely comfortably with him, however. Coming out of an on-site design team meeting one day, he expressed deep disdain for the role of the contractor manager who chaired the meeting. When I commented on the man's ability to 'keep it all in his head', Fraser's immediate and pained response was 'But that's *all* he does is manage!' There is a similar feel to a later comment: 'They [the contractors] will never get blamed because all they do is management contracting; the subbies [the subcontractors] do the work.' By implication, then, the *real* work is designing and building, not managing. So for Fraser, there is a tension between design and management, where for Karen it is between backroom and up front roles. But both of them experience the move into management as a move *away* from engineering. Fraser laments that he now gets to do less and less engineering (i.e., design), and frequently voices the heartfelt view that engineering should attract the same kudos and pay as management.

Science and technology are both part of Fraser's engineering identity. The science connection surfaces in the way he dualizes 'facts and politics'. Time and again he finds himself having to operate politically, but he is clearly more comfortable when he can 'stick to the facts'. Fraser presents the 'technological' part of his engineering expertise identity in terms of a focus on the design work. For example, in a telephone conversation with a contractor to whom the company is bidding in order to pair up for a major hospital project, Fraser says they need to talk 'with the people responsible for managing and delivering the thing as well as the nuts and bolts'. He then suggests 'an informal meeting with everyone chipping in … That's what I like. I'm more of a nuts and bolts person, than sitting talking about the thing. It's all about delivery at the end of the day'.

Design and Management

The story of this bid is interesting for what is illustrates about the troubled boundary between management and design.[9] There are two internal teleconferences – with three directors and two senior engineers, Fraser and Peter, from different offices of the company – to brainstorm their strategy for the bid. Everybody present recognizes that management and design need to be *integrated* if the design is to be 'delivered'. Yet the distinction between management and design runs throughout the preparatory discussions, with 'delivery' emerging as an ambivalent boundary term.

The management challenges in the hospital project are considerable. But whilst the team know they must have a convincing story to tell about this, time and again they come back to the need to demonstrate their 'design depth' – especially because the people they have to persuade in this bid are contractors. Tom emphasizes this: 'At some point, we will talk about design and delivery, and we will want depth in the meeting. … They will talk nuts and bolts. They'll want to know what your [waving to Fraser and Peter] duct drawings look like.' Peter has extensive experience of project management but, like Fraser, cleaves to a 'nuts and bolts' engineering identity – perhaps because he comes from a contracting background. He is asked to lead this side of the bid. Unlike Karen, Peter does not relish the role. He replies: 'Good designers don't necessarily do well up front. … I'm not necessarily the man for the job. I'm not comfortable with strangers. My confidence is in my technical ability'. Seeking to persuade him, one of the directors then suggests, 'I could be the project director, delivering some up front bullshit, alongside Peter as the bid manager'.

In some ways, the relationship between the directors and senior engineers is similar to that between engineers and architects. The two must be able to work effectively together, but without losing their respective strengths – the directors, their 'up front bullshit', business experience and networks of contacts; and the senior engineers their day-to-day, 'hands on' control and knowledge of design projects. The directors would find it hard to 'talk engineering' in specific detail with the contractors; they need the two senior engineers to be 'nuts and bolts' people in the context of the bid. But if the company *is* to deliver the eventual hospital design, Fraser and Peter will need to be what they in fact are – 'nuts and bolts and people' engineers – at which point their staff, and not they, are cast as the 'nuts and bolts' engineers.

We see here the fluidity of management-design boundaries within engineering. In both cases, engineers are attributed a technicist engineering identity in contrast to colleagues senior to them, while the directors and the senior engineers are managers, albeit with somewhat different management roles. At the same time, they are both still 'doing engineering' in these management roles. For example, Tom routinely reviews the designs of his staff and makes presentations of their work to architects or clients. In such ways, while engineers need interactive expertise in

[9] Notice how 'design' is used in relation to engineering when the contrast is with management, but in relation to architecture when it is contrasted with engineering.

relation to architecture, they use what Collins and Evans call *referred expertise* as managers.[10]

Gender Trouble Around 'Real' Engineering

Karen and Fraser have much in common beyond their shared discipline and age. Both are relatively senior, respected by their peers and managers alike; both are hardworking and ambitious; both do a lot of up front and managerial work and have good people skills; both have engineering identities rooted in science and technology; and both lament the loss of 'real' engineering work to some degree. The main difference between them is that Fraser is still trying to hold on to some of the 'nuts and bolts' work and has a strong sense of this as central to his engineering identity, whereas Karen is moving away from the 'nuts and bolts' of design and doesn't foreground this in her engineering identity. And in this particular company, Karen has had to leave in order to continue doing the type of engineering work she enjoys, whereas Fraser is likely to stay and progress through the ranks.

In drawing a comparison between the two, I do *not* wish to imply that Karen is typical of women engineers and Fraser of men engineers: plenty of men engineers happily gravitate away from backroom, design roles and plenty of women engineers prefer these roles. Rather, I see the cases of Karen and Fraser as illustrating *how gender symbols co-produce,* alongside professional drivers, *engineering identities.*

Most obviously, the 'nuts and bolts' identity paraded by Fraser and others takes its marker from hands-on work with technology; it is modelled on the technician engineer, virtually none of which are women. This identity therefore resonates with a working class 'muscular masculinity'. Its blue collar associations may be a particular draw for engineers in the UK, where professional engineering attracts more working class entrants than in other countries (Whalley 1986), many coming in through apprenticeships. In addition, the blue collar associations are especially prominent in relation to building contractors, who generally have a stronger working class presence and culture than does design engineering. Yet, even in countries where fewer engineers come from blue collar backgrounds, it seems common for men engineers to celebrate a 'nuts and bolts' identity. In their extensive study of engineers in the USA, Judith McIlwee and Gregg Robinson (1992) found that men engineers often engage in 'ritualistic displays of hands-on technical competence' even when the job does not require this competence.

So, the traditional association of men and engineering tools still marks professional engineering as masculine, which makes 'nuts and bolts' feel 'manly'. This does reflect a real, if diminishing, gender difference. 'Tinkering' with car engines and the like has long been a typical route into engineering for men (e.g., Mellström

[10] Thus: 'to manage a scientific project at a technical level requires, not contributory expertise to the sciences in question but *the experience* of contributory expertise in some related science' (Collins and Evans 2002, p. 257: emphasis original).

1995). Although a growing proportion of those now entering engineering do not come from a tinkering background, and although some women opt for hands-on work, still considerably more men than women engineers have been socialized into a hands-on relationship with technology. As many women engineers testify, this can seriously undermine their confidence and their sense of belonging, especially when they first enter engineering degrees.

The term 'practical' seems to me very gender-troubled in this context. As we have seen, both women and men engineers celebrate a 'practical' engineering identity – practical in the sense that as engineers they come up with solutions that 'get the job done'. Yet many of the women engineers I have met tell me, unprompted, that they are 'not practical' – practical in this context meaning that they do not have a strong background or interest in 'hands-on' aspects of engineering.

Significant though the 'hands-on' theme certainly is, the gendering of engineering identities is rather more complex than this, on a number of counts. For a start, women and men engineers both foreground technicist engineering identities, and science is an important marker of these identities for women and men alike. I sense that most women engineers foreground science more than 'nuts and bolts' in their engineering identities. This is not terribly surprising. The gender norms surrounding science are less strong these days than those surrounding 'nuts and bolts' technology, in the obvious sense that there are vastly more women scientists than women technician engineers. Yet, the strong emphasis on practical materiality – of designing things that work – is shared by all engineers. This is a unifying theme of both the 'nuts and bolts' and the 'laws of physics' versions of technicist engineering identities – and so cuts across the heavy masculine coding of the former.

Another source of gender complexity is that the two versions of 'real' engineering with which I opened this chapter are associated with two very available versions of masculinity. Where the technicist engineering identity takes its marker from science and technology, the heterogeneous identity takes its marker from corporate authority and business. It is modelled on the senior manager or entrepreneur, of which relatively few are women. Like engineering, senior management is a materially powerful role, but here the power wielded is a money power or organizational power rather than a physical power. A man engineer who moves into management may lose his credentials as a 'nuts and bolts' engineer, and unsettle the blue collar associations, but he does not lose his credentials as a man. If anything, he gains in this regard, since the authority wielded by managers, and the money made in business, are widely applauded markers of achievement in men (Connell 1987, 1995) – what Michel Kimmel (1994) calls *marketplace manhood.*

Why, then, does Fraser parade a technicist engineering identity even when his job is so heterogeneous? Why is he so reluctant to embrace an identity more consistent with his growing management role? Many oilfield engineers I studied also voice disdain for 'collar and tie' men. Two of them independently told me they dislike the career model that moves engineers from being specialists to generalists in management. Like Fraser, their gender identity is closely tied up with technology. If their ambitions could be met by staying in more narrowly technical roles, they would probably not opt to go into management. However, as well as being ambitious,

all three men get excited by (feel vicarious pleasure in) the 'money power' of the businesses they work for, which is precisely what management gets them closer to. So they are torn between identifying with technology and getting on in engineering, between the power of technology and the power of the corporation.

Of course, such ambivalence is not unique to the engineering profession. People in many walks of life have to move progressively into management and away from their original specialist skills if they want to progress their careers. These are organizational drivers. But I believe a further, gender dynamic may be operating here – namely, that the gender symbolism surrounding management is itself somewhat ambivalent. There are two, readily gendered dualisms operating here: hard/soft and technical/social. Note that the people skills required for management are widely referred to by engineers as 'soft' skills, in contrast to the 'hard' skills required for engineering. But management is also an arena of 'hard' commercial reality – readily cast as hardnosed, hard hitting and so on – as earlier quotes from Eilidh and Karen remind us. The gender connotations are clear. Management and business is likely to feel, and be perceived as, more 'masculine' (and more gender authentic for men engineers), to the degree that these roles carry real authority over others and/or deal with profit and loss aspects of running the business. Management and business is likely to feel, and be perceived as, more feminine (and more gender authentic for women engineers) to the degree that these roles draw heavily on interpersonal skills.

Where 'the technical' and 'the social' are gendered and presumed to be mutually exclusive, the technical/social dualism similarly creates tensions for men engineers doing or contemplating management roles. It means that identifying with 'the technical' (masculinity) means distancing oneself from 'the social' (femininity) – or at least playing down its importance, as Fraser does in relation to management. It also explains why management roles are portrayed as 'just' social by many women and men engineers. For men whose gender and engineering identity is tied up with technology, a move into management potentially undermines both their masculine and their professional identities.

The technical/social dualism also creates tensions for women engineers. On the one hand, it means that moving out of narrowly technical roles is likely to feel, and be perceived as, more gender authentic for them than for men. On the other hand, it means that those women who move away from the more narrowly technical aspects of engineering are in greater risk of losing their membership as 'real' engineers than are men who make the same move. Two older women engineers told me that women engineers who become senior managers are more likely to stop calling themselves engineers than are men who make the same move. It seems the gender authenticity issue never quite goes away for women in occupations dominated by men. Significantly, the tendency for women engineers to be invisible as engineers (cf Tonso 2007) can serve to reinforce a technicist identity amongst women engineers, many of whom choose to stay on the 'technical' side. After all, engineering generally attracts women who 'love technology' and all women engineers *per force* make a huge investment in becoming and belonging as engineers.

Evidence on the types of management jobs women and men engineers end up in reveals an interaction of the gendering of these two dualisms – hard/soft and

technical/social – in a pattern Mike Savage calls 'Women's expertise and men's authority' (1992). It seems engineering is typical of other occupations in that men disproportionately occupy positions of power and authority where they are involved in high level line management and the control of organizational resources, whilst women are disproportionately in management of support roles which demand specialist expertise (e.g., in charge of IT systems).[11] Women engineers also tend to get stuck in lower level management jobs, such as project or team management, which can be dead-ends in terms of progression into more powerful and remunerative seats of management (Evetts 1993, 1996).

The upshot of all this is that Fraser's membership as a 'real' engineer is likely to remain more solid, and Karen's more fragile, as they each move progressively from design into management. And Karen's move into management is more likely to be seen as – and sadly, in the case of her recent job move, to feel like – a move away from engineering, in spite of her obvious credentials on that front. In this regard, I would conclude, we *can* see Fraser and Karen and 'typical' of their gender.

Conclusions

We can now return to our opening challenge – to 'write gender in' to accounts of heterogeneity in engineering identities. A key question is: *why do engineers so often foreground a technicist engineering identity in spite of the lived heterogeneity of their actual work?* Clearly a key professional factor is that the 'core' expertise in scientifically-based analytical problems solving which engineers get from engineering education, in their unique professional contribution in a networked design process. But there are also two critical gender factors operating here.

First, technicist engineering identities are as strong as they are in part because these identities converge with available masculinities, in at least two ways: they brings them close to a sense of hands-on technical work (even though they rarely do this themselves); and it makes them feel powerful (they make 'buildings that work'). Thus, many men engineers cleave to a technicist engineering identity because it feels consistent with versions of masculinity that are comfortable for them. Whilst most women engineers also take pleasure in and identify with the material power of the technologies they build or work with, the majority nonetheless identify more readily with the science base of engineering than with hands-on engineering.

Second, the conventional gendering of the technical-social dualism simply cannot be ignored if we are to understand the strength of technicist engineering identities – and, by this token, the continued predominance of men in engineering. The technical/social dualism makes it easier for men to identify with the 'nuts and bolts' of engineering, and casts people skills as 'soft', for women. The tendency to see 'the technical' and 'the social' as mutually exclusive is likely to reinforce some men's resistance to embracing a heterogeneous engineering identity. In any case, presenting

[11] See also Halford et al (1997) on gender segregation of management roles in other sectors.

as a 'nuts and bolts' person is rather more 'gender authentic' symbolically for a man than for a woman in our culture; just as moving away from the 'nuts and bolts' is rather more 'gender authentic' for a woman than a man. Little wonder that women's membership as 'real' engineers is often more fragile than that of men colleagues.

Notwithstanding the pull of technicist identities, engineers routinely experience contradictory impulses about how much of 'the social' is admitted in their engineering identities and in what counts as 'real' engineering. A second key question, then, is: *why are the tensions surrounding the two versions of 'real' engineering so apparently intractable, and what are they about?*

Again there are gender dynamics operating alongside professional and organizational ones. Professionally and organizationally, there is a tension between the need for engineers' 'core' expertise in maths, science and technology, and the need for them to also be able to collaborate and communicate effectively with the other partners in a networked design process. In a similar way, there is a mutually dependent but partially overlapping relationship between those engineers who do more design and those who do more management.

The gender tensions operating around technicist and heterogeneous engineering identities concern men and women engineers in different ways. For men engineers, tensions can flow from the fact that the two versions of masculinity that these engineering identities map so readily onto are *very distinct*: one associated with technology, the other with business. Although these are both in some sense hegemonic masculinities, they are not necessarily compatible for all men, as Fraser's story illustrates. For women engineers, tensions can flows from the very gender inauthenticity of the woman engineer, which means that women engineers have a constant struggle to prove that they are not only 'real engineers' but also 'real women' (Faulkner 2009a). In this context, moving away from narrowly technical roles is a case of 'damned if you do, damned if you don't'.

My central conclusion from this analysis is that engineering as a profession must find ways to foreground and celebrate heterogeneous understandings of engineering and heterogeneous engineering identities. There are two really strong reasons for this conclusion.

First, that is what engineering is! Every aspect of engineering is heterogeneous; even the most apparently technical roles have social elements inextricably within them. Moreover, *good* engineering (as in engineering which is effective) demands the thorough integration of these elements, in ways which *transcend* the normal dichotomizing ways of thinking. Witness, Eilidh's mission to integrate 'hard' and 'soft' elements in sustainable building design; and the hospital bid team's mission to integrate management and design if the hospital is to be 'delivered'. The crucial and (for some) radical challenge is to convey that all engineering is, of necessity, *both* technical and social.

Second, foregrounding and celebrating more heterogeneous images of engineering can only serve to make the profession more inclusive. Engineering encompasses a wide diversity of roles, in which the relative weight of technical and social elements (amongst other things) varies along a spectrum. Within this 'broad church', individuals tend to gravitate to roles which suit their particular skills and personality.

As we have seen, some are more comfortable with the 'up front' roles and others with the 'backroom'; some are more comfortable interacting with contractors and suppliers, and others with architects and clients. If the profession does not promote an identity for itself which welcomes this broad range of interests and aptitudes, then it will fail to attract some very valuable talent. And if the profession remains a 'mono-culture', in which only people from one spot on that spectrum really feel they belong, then it will lose some very valuable talent.

So, promoting heterogeneous images of engineering will create space for a more diverse range of people to be engineers. If such moves are to be more *gender* inclusive, however, they must also challenge the gendering of 'the social' as feminine and 'the technical' as masculine – and thus promote new 'co-constructions' of gender *and* engineering simultaneously.[12] In the words of Evelyn Fox Keller many years ago (1986), we need to learn to 'count past two'. Counting past two is about challenging the very dualisms that (re)produce women and men as necessarily different, and engineering as necessarily technical or social. As my ethnography of building design engineering demonstrates, heterogeneous engineering requires heterogeneous genders – in the sense that it requires various mixes of stereotypically masculine and feminine strengths.

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[12] This represents a challenging message for 'women into engineering' campaigns, many of which draw on gender stereotypes by playing down the technical content of engineering and playing up the social content. Lagesen (2007) demonstrates that playing to such stereotypes can 'miss the mark' for the young women being targeted.

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