The Good, the Bad and the Ugly: Women engineering students' experiences of UK higher education

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Publication details:
Women and Minorities in Science, Technology, Engineering and Mathematics: Upping the numbers
pp. 47-70
978-1-84542-888-4 (ISBN)

Publication Date:
2007

PART II

Experiences of women and minorities in STEM

3. The good, the bad and the ugly: women engineering students' experiences of UK higher education

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INTRODUCTION

The UK engineering industry is quantitatively and hierarchically male-dominated. This is significant given the societal importance and impact of engineering on people's lives. Engineering has a popular image of being tough, heavy and dirty, and from a student's point of view, hard sums and greasy metal. These powerful cultural images have helped to reproduce occupational segregation whereby engineering has been perceived as unsuitable for women. Despite these widely held views, some women do decide to study engineering with the possibility of pursuing a career in the sector.

This chapter explores how some of these women experience engineering in higher education (HE) in the UK. The first part examines the issue of women in engineering and engineering education, highlighting the importance of increasing the number of professional women engineers. The second part investigates the cultures that persist in engineering and higher education generally which act as barriers to women's progression, before addressing specific cultural factors in engineering education that may hinder women's advancement to the engineering professions. The final part of the chapter sets out the findings of an Economic and Social Research Council project into these issues. It begins by describing the methodology used and proceeds to analyse women's experiences of UK engineering education in terms of the good, the bad and the ugly. These terms are explained using examples from the research findings later in the chapter.

WOMEN IN ENGINEERING

Nancy Lane, co-author of 'The Rising Tide' report on women in science, engineering and technology (SET), has commented that 'Engineering . . . is a subject where women are currently catastrophically underrepresented' (1997, p. 41). That women remain a minority in engineering has been explained in various ways, including poor or inadequate career guidance before starting university; early differential socialization of males and females; lack of support from family, friends and professional engineers; and cultural and occupational barriers (Dryburgh, 1999). Sagebiel (2003), for example, argues that studies in Europe and elsewhere have shown that women are driven away from technology not by inability in abstract thinking but by the prevailing content and climate, which construct an atmosphere of dominant masculinity.

Bagilhole (1997) has maintained that there is a business case for the increase of women in male-dominated work spheres. This essentially rests on two premises: that the industry is under-utilizing the full range of skills and talents in the population because of continuing unequal opportunities for some groups in society; and that it should be possible for organizations to increase their efficiency and effectiveness by projecting a more pluralistic self-image, thereby widening their pool of potential customers. The beneficial effects of identifying and removing discriminatory practices are direct and quantifiable, and include the reduction of costs related to staff turnover, reduced litigation fees, and accessing largely untapped reserves of skill and talent through a wider pool of applicants. Indirect benefits include improved customer service and enhanced staff morale (Dainty et al., 2004).

Over the past two decades, a number of government initiatives have been established to increase the numbers of women entering engineering education and employment. In 1984 the Women into Science and Engineering (WISE) campaign was established, promoted by the Equal Opportunities Commission and Engineering Council. The Engineering Training Authority (EnTra) has taken positive action to recruit girls and runs an Insight programme (a week-long residential course) designed to facilitate this. Approximately 40 per cent of those attending the Insight course subsequently choose to attend engineering courses at university (Opportunity 2000, 1996). The Construction Careers Service, a part of the CITB (Construction Industry Training Board), also has a number of initiatives to heighten awareness in the construction sector. These include work shadowing, provision of speakers at careers events, free brochures, videos and literature, careers seminars for teachers and careers advisers, school/industry links, and curriculum centres (Gale, 1994).

While these initiatives are commendable, and have been effective in attracting women to the industry (Dainty, 1998), such measures are a response to skill shortages in technological expertise, rather than a determined drive to tackle the gendered culture of the industry (Walker, 2001), which will be discussed in more detail below. In this case it may be appropriate to question whether more women should be encouraged to become engineers, given the problems they are likely to face in the industry (Carter and Kirkup, 1990). Furthermore, Etzkowitz et al. (2000) have indicated that policies to increase numbers of women in engineering are not sufficient, as it does not automatically mean a change in culture (for further discussion of the 'critical mass' debate see Powell et al., forthcoming).

WOMEN IN ENGINEERING EDUCATION

Initiatives such as those described above have had some success in increasing the proportion of women studying engineering. Glover (2000) reported that in 1973 only 3 per cent of engineering and technology undergraduates were women. This is compared to 15 per cent in 2004/05 (HESA, 2006). However, figures vary widely by subject, with highs of 68 per cent and 60 per cent in polymers and textiles and ceramics and glasses, respectively, and lows of 8 per cent and 10 per cent in mechanical and electrical engineering respectively (HESA, 2006). The proportion of women studying engineering not only remains low in comparison to other subjects (only 1.6 per cent of all female students in HE are based in engineering, HESA, 2006), but the increase in women engineering students has failed to translate into an equivalent increase in female engineering professionals, with suggestions that less than 10 per cent of professional engineers are women (Fielding and Glover, 1997). More recent estimates suggest that women only account for 6 per cent of engineers and technologists in professional or associate professional and technical occupations (ONS, 2000). This is also despite recent research funded by the Scottish HE Funding Council indicating that although numbers may be low, female engineers are generally perceived to be better qualified and more highly motivated than their male counterparts, and at graduation women often receive numerous job offers (SHEFC, 1997).

CULTURE

Much of the above analysis indicates that the difficulties women have penetrating the engineering industry may be a result of the deep-seated culture ingrained within engineering organizations. Evetts (1997), for example,

considers that cultural aspects and gendered images have been important in explaining statistical differences between men and women's career achievements. This section will, therefore, further investigate organizational culture and the relationship between organizations and gender, as well as looking specifically at the engineering culture.

How we choose to define culture has important consequences for how we attempt to examine it. Brown (1995) writes that there are many different definitions of organizational culture, although most commentators have chosen to think of culture as an objective entity. Agreement on this, however, still leaves room for a broad spectrum of opinion on other details. According to Pacanowsky and O'Donnell-Trujillo (1982), an organization *is* a culture, and all features of an organization, including its systems, policies, procedures and processes, are elements of its cultural life. While this is an intellectually coherent position, many theorists have resisted it, because if everything is culture, it is impossible for the concept to frame causal explanations of other aspects of organizational activity. In contrast, other authors, such as Schein (1985), have suggested that culture is best thought of as a set of psychological predispositions that members of an organization possess, and which leads them to think and act in certain ways. While the view that culture is essentially a cognitive phenomenon residing in the psychology of organizational participants is widespread, many theorists, such as Eldridge and Crombie (1974), acknowledge that patterns of behaviour are equally important. Brown (1995, p. 9) chooses to define organizational culture as 'the pattern of beliefs, values and learned ways of coping with experience that have developed during the course of an organisation's history, and which tend to be manifested in its material arrangements and in the behaviour of its members'.

Gender is fundamental to the culture of organizations, as has been shown in studies in other sectors (for example, Ledwith and Colgan, 1996). Itzin (1995) described organizational culture as hierarchical, patriarchal, sex-segregated, sexually divided, sexist, misogynist, resistant to change, and to contain gendered power structures. Hofstede (1984) contends that masculinity forms a key element of corporate culture. West and Zimmerman (1987), for example, suggest that men and women 'do' gender in social interaction, despite perceiving that they act in gender-free or gender-neutral ways. Since people bring their beliefs about gender into social relations with little thought, gendered performance is pervasive and taken for granted (Ridgeway, 1997). While participants in organizational culture may believe they express personal taste and inclinations, Gherardi (1994) maintains that knowledge of what fits with the organizational style is an acquired skill. Gherardi therefore argues that the way we 'do' gender in work can help diminish or increase inequality between the sexes.

Engineering Culture

The central role of engineering in society and the economy is not evident to the public at large, nor to the media in particular. The engineering profession is, according to Malpas (2000), considered by many as a somewhat dull, uncreative activity, associated with the so-called 'old economy'. Historically the image of engineering has been tough, heavy and dirty, and to do with machinery. In terms of cultural image, engineering is perceived as a masculine profession. This is not only because the workforce is male, but because the prevailing culture and ethos of the industry appears to be extremely male (Gale, 1994). These cultural images have remained powerful and have helped to reproduce the perception that engineering is unsuitable for women (Evetts, 1998). This is a somewhat cyclical process, reinforcing the masculinity of the industry. It has been argued that this is a result of the polarized characteristics supposedly attached to gender in the process of socialization. Sagebiel (2003) states that engineering can be considered gendered in three ways. First, gendered structures are visible in gender difference in the division of labour and in the work styles of women and men. Second, the symbols and images of engineering knowledge and practice are gendered through cultural associations between masculinity and technology. And third, individual engineers have gendered personal and professional identities and experiences.

It is also the case that women suffer if they go against such cultural dictates (Evetts, 1998). This is supported by Glover et al. (1996), who indicated that women actively choose not to enter SET careers in the knowledge that they are likely to feel discomfort. This is because when women undertake 'male work', they upset a widely accepted sense of order and meaning (Cockburn, 1985). Although women can cope with the actual engineering work, they are likely to find it much more difficult to cope with the engineering culture (Evetts, 1998). Some women therefore pay both personal and social costs when they cross the threshold into a male domain. Opportunity 2000 (1996) suggests that this is because young women in science and engineering, for example, find themselves working with the values, systems and performance criteria that have been set up by men for men, and not for women.

By contrast, Bennett et al. (1999) claim that women who seek a career in the construction industry are socialized into its culture through the education system and appear actively to seek that culture. Gale (1994) described gender values as a continuum ranging from male to female and suggests that women holding similar values are attracted to similar occupations. Bennett et al. (1999) do, however, concede that the reverse is also true: many women reject the construction culture as acceptable, as do many men.

HE Culture

The Hansard Society Commission Report (1990) described British universities as male bastions of privilege and power, and claimed that women's chances of entry, promotion and retention are generally lower than women's. Morley (2000) argues that academia maintains its gendered power relations through everyday practices such as bullying, stalling, sabotage, manipulation and spite. Such occurrences appear trivial, subtle and difficult to capture, but at the same time they reveal the ways in which competition and domination are played out. According to Morley, the study of micropolitics in HE can illuminate ways in which organizational power accrues. Even in countries that are considered to be at the forefront of promoting gender equality, such as Finland, women still encounter subtle forms of discrimination (Husu, 2001).

Bebbington (2002) suggests that the pattern of vertical segregation (the further one goes up the hierarchy, the fewer the women) persists in all disciplines, including business, social studies and language-based studies. There are nevertheless disciplinary differences, with women best represented in language-based studies at almost every grade and worst represented in engineering and technology.

Bagilhole and Woodward (1995) have shown that sexual harassment is an underrecognized and underestimated phenomenon in the UK academic profession and a strong indicator that the problem lies with the academic culture. Morley (1999) argues that employment issues are highly linked to epistemology, with discrimination against women perpetuating and upholding the male perspective in academia.

Davies and Holloway (1995, p. 13) found that in the HE sector, 'equal opportunities . . . is seen very much as an employment issue, and not as an issue which relates to the delivery of educational courses and research'. This is a serious omission because, as Weiner explains, the curriculum is 'of crucial interest because it highlights and problematises taken for granted assumptions about knowledge, gender and culture . . . it is socially constructed and as such, is both a reflection of dominant ideas and a place where these ideas are played out or resisted through practice' (1994, pp. 3–4). However, there are some exceptions. Thomas (1990), for example, looked at the relationship between the 'culture' of certain subjects and how women and men students related to them, exploring gender relations in the context of specific curriculum discourses and practices. She found that female science students saw themselves as a homogeneous group that was different and uncomfortably visible in 'a masculine preserve'. Evans (1995, p. 73) argues that because 'control, rather than consumption [of the curriculum], is in the hands of men . . . the very assumptions of

the academy – its claims to universal and generally applicable knowledge – have to be challenged'. Bagilhole and Goode (1998) suggest that male academics have defined not only what is taught in universities, but also how it is taught, in a way that marginalizes women.

Despite some re-evaluation of curricula, Bagilhole and Goode (1998) have found that changes in the actual practice of curriculum design, staff–student interaction and assessment are slower and more patchy in traditional institutions of learning, such as 'old' universities, where questions of epistemology and pedagogy have gone largely unexamined. They suggest that the innovation now taking place in universities seems to have come from three directions. First, equal opportunity (EO) specialists are now beginning to undertake EO audits of the curriculum. Second, where women scholars are themselves represented, *completely new curricula* have appeared as a result of feminist endeavours. Third, in the traditionally male-dominated science and engineering disciplines, concerns have centred around *access to subjects* where female representation is poor. Bagilhole and Goode (1998) also found that individuals could operate either a 'narrow' or 'broad' definition of the curriculum, whereby the curriculum might be taken as simply referring to the topics to be covered in a particular course/module or the whole process of teaching and learning and all the activities in their various contexts which take place during that process.

HE Engineering Culture

Mills and Ayre (2003) suggest that there have been a number of findings that many women experience a 'chilly climate' in SET courses, and it is likely that other minority groups share similar experiences. Unhappy or uncomfortable students are unlikely to achieve their full potential and may even leave the course. Some of the features of the 'chilly climate' identified by Mills and Ayre (2003) include:

- false assumptions by lecturers that all students have prior 'tinkering' experience (practical familiarity with technology, equipment and appliances) (Lewis, 1995);
- lack of excitement in the content or presentation of the course (Nair and Majetich, 1995);
- apparent lack of relevance in the curriculum content (Lewis, 1995; Lintern, 1995);
- teaching methods that are appropriate for only a very limited range of learning styles (Lewis, 1995; Jolly, 1996);
- disruptive behaviour of majority groups (e.g. white male students throwing paper planes) (Lintern, 1995; Jolly, 1996), and

- classroom atmosphere uncomfortable for some students because of racism, sexism, or similar attitudes (Lewis, 1995; Lintern, 1995; Jolly, 1996; McLean et al., 1997).

On the other hand, McIlwee and Robinson (1992, p. 50) argue that engineering HE culture values academic work at which women excel, and that it is engineering workplace cultures that value such masculine strengths as 'a fascination with technology, expertise as a tinkerer, and an aggressive style of self-presentation'. They argue that knowing how to conform to the masculine engineering culture and doing it well are critical to women's success in the workplace. However, they consider that this only becomes an issue when women make the transition from education to work. They believe that in the workplace women engineers not only have to show competence in their knowledge and skills, but also have to learn to perform and enact masculine norms of attitude and interaction. While this is not disputed, McIlwee and Robinson fail to recognize that the very knowledge and skills women learn in engineering education, or at least the ways in which these skills are taught and learnt, also encompass masculine norms and attitudes.

Sagebiel (2003) argued that an improved curriculum could make both the climate and content of teaching appropriate to attract and retain both men and women. Brainard et al. (n.d.) suggest that improved teaching is particularly relevant to women and that men are less affected by poor teaching, poor organization of course material and by dull course content. The US National Council for Research on Women report (Thorn, 2000) has shown the importance of the first year for women having entered engineering in HE. Since women tend to evolve an interest in technology over time, the typical first-year 'killer' exams designed to weed out students rather than invite their participation may be counterproductive for retaining female students. Copeland (1995, p. 18), however, indicates that 'recognising the different skills, perspectives and learning styles that women bring to engineering and incorporating these into the teaching and learning environment' means challenging the assumptions and practices within engineering itself.

Part of the problem may be that once the decision to study engineering has been made, commitment to the field does not automatically follow. Etzkowitz et al. (2000, p. 133) show that educational experiences have a cascade effect on commitment: 'A cascade of affirming experiences serves to amplify a string of positive effects, until there is a short-circuit and the process is reversed . . . what had the potential for a cumulative positive cascade of experience becomes short-circuited by negative experiences.'

Lewis (1995, p. 270) found engineering teaching to be strongly male biased: 'The research questions, methods, criteria of success, and styles of

teaching are male defined, and consequently, the knowledge itself reflects a bias towards a male cognitive style in its practices, theories, and ways of teaching.' This is a worrying trend given that Mills and Ayre (2003) emphasize the desirability of structuring an engineering curriculum around a general recognition that students from diverse backgrounds bring different perspectives, attitudes and values to the engineering classroom, without making distinctions between the specific cultural groups represented in the class. This is supported by Sagebiel (2003), who suggested that an improved curriculum would make both the climate and content of teaching appropriate to attract and retain both men and women. Improved teaching is particularly relevant to women, as the WEPAN (Women in Engineering: Programmes and Advocates Network) policy climate survey, exploring the environment for undergraduate engineering students, found that men are less affected by poor teaching, poor organization of course material and by dull course content (see Sagebiel, 2003).

Thomas (1990) showed that disillusionment among students has arisen through excessive maths and quantitative content, narrowness and the abstraction of the curriculum, lack of relevance to the 'outside' world, too early specialization and the need to conform to rigid rules, without the opportunity to challenge them. This has led to passive learning, acceptance of facts on trust, and frustration. In terms of the learning context and curriculum, both Greed (1991) and Thomas (1990) describe the impersonal and indifferent atmosphere of science and technology departments. This is manifested, for example, in formal teaching methods and the interpretation of professionalism in masculine terms. As Byrne (1987) points out, teaching styles in science and technology are instrumental and non-negotiable. As a result of these methods of teaching there is little debate, interaction or concern for the aesthetic.

Madhill et al. (2003) write that career decision making is affected by a number of factors, of which hands-on experience is particularly influential. Without the opportunity for hands-on learning, students report that they do not automatically appreciate the application of what they are studying to their personal aspirations and the things they care about. Many students in Srivastava's (1996) study also pointed to the lack of opportunity for practical work. They felt that the emphasis on broad, theoretical, historical and textbook contexts was irrelevant, limited in usefulness and remote from industry.

Mills and Ayre (2003) suggest that the typical engineering curriculum has been blamed for the difficulties in recruiting and retaining female engineering students. Beder (1989) describes it as showing an 'obsession with the technical, the mathematical, and the scientific, and an almost complete neglect of the social, political and environmental issues' which discourages

'students with broader interests, a different range of talents . . . ; those who want to work with people rather than machines and numbers, those who care about social relations. Too often it is the female students who are put off' (Beder, 1989, p. 173). Thomas (1990) also suggests that HE curriculum is male-centred. She shows that subjects are not neutral but gendered in that they are socially and culturally constructed.

Using construction as a specific example of a SET subject or discipline, Srivastava (1996) recommended a number of changes be made to the HE curriculum. These included presenting construction disciplines in a social context; considering practical applications; integrating modules from social sciences and humanities; questioning assumptions, traditions and the culture of construction education and practice; relating topics to a range of student experiences; addressing the social and environmental impact and benefits of construction; incorporating interactive, qualitative, critical and ethical considerations in projects; and mentoring of students and staff who are in a minority. She also suggested that feminist perceptions of science and technology should be incorporated into the construction curriculum, to facilitate questioning of assumptions, and challenge conservatism and traditionalism in the construction curriculum industry. There should be further easing of professional bodies' influence on construction course design and content, and more autonomy given to construction tutors to make space in the curriculum for new and more relevant areas, and also for independent study, reflection, discussion and debate.

Bagilhole and Goode's (1998) research found that in science and engineering faculties a narrow definition of the term curriculum was predominantly in use, seen as referring to a well-defined body of knowledge which was to be transferred to students largely by lecturing. This is in line with Thomas's (1990) study, which showed science departments characterized by a formality of pedagogy which involved the definitive authority of lecturers and the passivity and dependency of the students, the predominant use of the lecture, the abstract nature of the subject content, and the heavy amount of prescribed and controlled laboratory work. Bagilhole and Goode found that although concerns in science and engineering departments centred around access, in practice this referred to access to courses, in terms of recruitment of undergraduates, and did not encompass access to the curriculum itself, or considerations of how far there are differential curricula and therefore differential access to and engagement with particular aspects of the curriculum.

Bagilhole and Goode's study showed that awareness of issues in curriculum innovation was highest in the social sciences and humanities where a gender dimension had been introduced into the curriculum. However, departments with few women students or staff failed to recognize the issues.

Bagilhole and Goode identified that the main problem in these departments was with the common view that any 'problem' lies 'out there' rather than 'in here', alongside a view that women undergraduates were going to have to operate in the 'real world'. The university was seen therefore to serve them best by equipping them, while they were there, to cope with rather than to challenge discrimination when they leave.

Bagilhole and Goode consider that the educators in the engineering world are stuck in an increasingly outdated mould. It is perceived that women need to change to accommodate industry, not the other way around – women must learn to adjust to industry, cope with it, become fitted to it. Women engineering undergraduates at the university in their study were apparently learning to be discriminated against. The role of the university was seen simply to prepare them for 'real life' and anything else was seen as unfair. Both the formal and informal curricula remain gender-blind in their operation – and in the name of equality are treating all students 'the same'.

METHODOLOGY

The research presented in this chapter is based on an Economic and Social Research Council funded project aimed at developing an understanding of women engineers' earliest encounters with engineering workplaces on their future career intentions. Workplace experiences were examined in the form of the year-long industrial placement taken in HE, as this usually represents women's first main contact with the engineering industry. A major part of this research also included an investigation of women students' experiences of engineering education across a range of engineering and related disciplines, including construction/civil, aeronautical, mechanical, design and technology, and materials. The research adopted a longitudinal, mixed methods approach, combining interviews, focus groups, documentary analysis and a questionnaire.

The initial stage of the research used a qualitative approach to explore the experiences and reflections of women engineering students. Two semi-structured interviews were conducted with 26 industrial placement students at a pre- and post-1992 university. Access to students was facilitated through university databases and industrial placement coordinators in each of the engineering, or related, departments at the two universities. The use of a semi-structured interview schedule for both sets of interviews meant that key issues identified by the researchers (e.g. influences and reasons for undertaking their particular degree, experiences of their learning environment, the transition to work, placement experiences, future

career intentions, and so on) could be explored, while at the same time interviewees could define issues according to their own experiences and understandings. Following this stage, two focus groups of the same women were conducted. The purpose of the focus groups was to explore how women's attitudes and career intentions had changed as a result of the placement process, and to allow the women to compare and contrast their experiences. Only 13 of the original cohort participated in the focus groups, as a number of women dropped out of the research due to other commitments having to take priority.

The pre-placement interview stage of the research was complemented by including an additional 26 interviews with women students at the pre- and post-1992 universities who had chosen not to go on industrial placement. These interviews explored similar issues to those described above, as well as investigating women's decisions not to go on placement. Access to these students was facilitated through university databases and programme coordinators.

The interviews were tape-recorded and the focus groups video-recorded, then transcribed verbatim and anonymized, before being analysed with the computer software NVivo. NVivo was used to employ an approach informed by grounded theory, searching for meaning in the data and generating theory from rich, detailed descriptions in the interview transcripts. The initial analysis began with open coding, breaking down, examining, comparing, conceptualizing and categorizing the data (Strauss and Corbin, 1990); axial coding then ensured relationships between categories were systematically developed and that all similarities and differences were captured in the final analysis (Langdridge, 2004). The cumulative analysis of findings led to the eventual development of theories and explanations grounded in the data, reflecting the complex nature of the social phenomena investigated.

FINDINGS AND DISCUSSION

The research revealed a number of findings relating to women students' experiences of engineering in HE, which range from 'good' to 'bad' to 'ugly'. The findings under each of these headings are elaborated below, although it is important to note that findings are not exclusive but intertwined and mutually reinforcing. Interestingly, a number of the findings concerning women's attitudes are also contradictory, indicating that the themes discussed below are operating on a subconscious level for the women involved in the research and as a result of negotiating complex discourses concerning their relationship with gender and engineering (French, 2005).

The Good

The majority of women engineering students interviewed were positive about their career choice and their courses. The 'good' aspects of studying engineering at university were described as peer camaraderie and relationships with other students, the support of lecturers and personal tutors, and the opportunity to undertake an industrial placement between years two and three of the degree programme.

One particularly favourable aspect about engineering programmes was deemed to be the student relationships and camaraderie, a view often expressed with comparison to other courses:

> All my course mates, they're really friendly and helpful, not like some other courses. Some other courses they don't know who are on the course and they don't communicate. (Victoria, Chemical Engineering student)

> The best thing is the people you meet. They're all kind of like minded . . . because it's such a difficult degree everybody helps each other, like when we've got a really tough piece of coursework . . . the people who've done it will come over and help the people who haven't. It's a really nice spirit amongst everyone. (Jenny, Aeronautical Engineering student)

This is possibly a result of the levels of group work and the volume and intensity of the work involved in engineering programmes (although, as will be shown later, these women students were more critical of these issues in themselves).

Women students were found to praise lecturers, with most students finding them approachable, supportive and motivating:

> Some of the lecturers are quite good and it makes you think, I want to go into the industry, because they've been in the industry before . . . he'll tell you what sort of things have happened, and how it can be fun and exciting and it can sound very interesting. (Frances, Air Transport Management student)

> There's always the support there and the lecturers are really good. If you've got a problem you can always go and find them and get help. (Sophie, Mechanical Engineering student)

The same praise was afforded to personal tutors too, although less frequently, possibly as a result of the under-utilization of the personal tutor system. However, students' positive regard of personal tutors suggests that it is an area that should be encouraged and promoted within the university system.

> I really feel like [personal tutor] really looks out for me. And I see him more as a final student or big brother figure. (Katie, Industrial Design and Technology student)

Women students also favoured the diversity of engineering courses, often citing this as a reason for having chosen to study engineering over other courses:

> I think there's always something different you know, there's never two days the same. (Diana, Mechanical Engineering student)
>
> With aeronautical . . . I liked it because it was so broad, you learnt everything from, you know, electrical to mechanical to, you know, say systems and programming. (Emily, Aeronautical Engineering student)

However, this also created something of a dilemma for students, who, while valuing the diversity of their courses, often found it difficult to recognize the relevance of aspects of the course and criticized the volume and intensity of their work load, as will be demonstrated later.

The opportunity and experience of taking an industrial placement was also perceived as advantageous. The placement was perceived as an opportunity to experience a side of engineering that cannot be taught or replicated in the classroom. It also had the potential to ease students' transition to engineering employment by familiarizing them with the engineering workplace.

> [The placement] shows that you have got some idea [that you are] grounded in industry rather than saying I know all this theory like everyone else does. You can apply it, know what's needed for what. (Hayley, Mechanical Engineering student)
>
> [The placement will] be learning about the whole different way of how it all works and meeting different people, earning some money, and being one step closer to actually being independent. (Lisa, Materials Engineering student)

Generally, university support for finding placements was viewed well, although provision for this varied between departments. For further discussion of women's experiences of the engineering placement see Powell et al. (2005).

Although some students chose not to go on placement, this was usually for personal reasons such as having had industrial experience before starting university, being restricted to a particular geographical location, or not wanting to lose friends from courses who didn't go on placement, rather than viewing the placement as worthless.

The Bad

Women students were, however, found to be more critical of structural issues, such as the teaching and learning methods on their engineering

programmes. Criticism was particularly directed at curriculum content and the relevance of particular modules:

> Some of the work we do, you're like why? Why do I need to know this? Or, why are we learning it now? I think we could have spent more time on other stuff. (Hannah, Civil Engineering student)

> Sometimes . . . you think what the hell is going on here? When you're doing this crazy maths you think 'what does this apply to?' But you've just got to ask, 'what's this in real life?' and then they'll tell you. (Tracey, Aeronautical Engineering student)

Negative perceptions of the volume and intensity of work involved in engineering were particularly forthcoming on the Industrial Design and Technology course:

> It's been a lot more hours than I thought it'd be, it's like 24-7, just working. I've got lectures most of the day, and then I'm working at night to do the stuff that they've set us in our lectures. (Jessica, Industrial Design and Technology student)

> The worst things are the amount of work . . . we have a lot of deadlines in at the same time. You don't get much sleep at all. A lot of the work is very time consuming . . . there's always an on-going project. But then, I suppose that's something I like anyway. (Elizabeth, Industrial Design and Technology student)

The women students also complained about the lack of practical work. While most students realized that theory was an essential part of the learning process, they also believed that practical hands-on work could play a greater role in the course:

> I expected it to be a bit more practical. The theory isn't too bad, but there's so much to take in and to understand . . . I think for me, I'd personally like a bit more of the practical. (Chloe, Mechanical Engineering student)

Students also had a tendency to prefer coursework to exams, although it accounted for very little of the assessment:

> I think the worst thing is definitely the exams, because they were so hard, and I worked really hard for them . . . I think the people that are more practical are probably the people who don't do so well in these exams. They are so theoretical. (Samantha, Civil Engineering student)

These experiences are not entirely surprising given that Lewis (1995) described the teaching and learning methods that make up the structure of engineering HE as 'strongly male biased'. While students' opinions in the

research are not as strong as those described in the literature, it is evident that the women students did not always approve of, of feel comfortable with, curriculum content, assessment methods, the volume of work and the emphasis on theory, rather than practice.

Possible solutions to the traditional teaching and learning methods in engineering and related courses involve, among other things, introducing greater choice for students, such as the option to choose management or social science modules, or 'softer' engineering modules that address the social and environmental impact of engineering, as suggested by Srivastava (1996). The difficulties with this are that core modules may have to be dropped to make way for change; the volume of work the students had was considered overwhelming, so to introduce additional modules would be unrealistic. However, on many courses the modules and topics covered are dictated by the professional bodies that accredit courses (students also need to cover certain areas to get Chartered Engineer status), which are unlikely to favour the introduction of optional modules. The ethos and rigidity of the system in engineering therefore implies that if individuals want to achieve in the sector they must conform to existing masculine norms and attitudes (McIlwee and Robinson, 1992). Furthermore, with regard to the lack of practical engineering, Short et al. (2003) have written that where students are able to see the reality of engineering and the application of their knowledge to real engineering problems, their enthusiasm can more easily be generated, suggesting that such an improvement to engineering programmes would benefit all students regardless of gender.

The Ugly

The findings described as 'ugly' relate less to the structure of engineering education and more to non-structural aspects of the engineering culture, such as people's attitudes towards women in engineering. It is felt that these aspects are particularly detrimental to women students and their commitment to engineering. These everyday occurrences build up to the point where some students decide engineering is not for them.

In contradiction to the favourable remarks concerning camaraderie among engineering students, women students were also found to have difficulties communicating with male students and staff, and being taken seriously when it came to work:

> Trying to get the boys to listen to anything you're saying is difficult . . . the boys just wouldn't listen to a word that Rachel was saying . . . I had to persuade them to listen to what she was saying, and I found that really frustrating that they just wouldn't listen. (Emma, Mechanical Engineering student)

> Communication was non-existent and I was left out in one way or another. They wouldn't tell me there was a group meeting . . . It was peer assessed . . . they marked me right down, which I felt was completely unfair because within the boundaries they'd placed on me, I'd done the best I could. (Andrea, Civil Engineering student)

While students generally thought that group work was beneficial, poor communication appeared inherent. This is somewhat paradoxical given that group work at university is presumably intended to improve communication skills for the workplace. There are two possible explanations here. First, students are not taught how to do or manage group work, but it is expected that they will learn through practice. Second, it may be that collaboration and teamwork is ineffective in HE because of the individualistic nature of the university system, where students achieve, and are awarded degrees, on the basis of individual merit.

Relationships between staff and female students and staff and male students were often perceived as unequal. This was particularly apparent with regard to tutorial and laboratory work, where some members of staff, often technicians rather than lecturers, were found to give more help to female students:

> It's nice [tutors] go all out to help you, but it can feel sometimes that it's because you're a girl that they go all out to help you and it can be a little bit sleazy. One guy . . . he's just really unbelievable. He'll take you from the back of the queue, bring you right in front of all these lads and help you – pretty much do it for you, which you're not going to complain if someone's offering to help, but then you get grief off the lads . . . they put you at a disadvantage. (Fiona, Industrial Design and Technology student)

However, one student legitimized this, suggesting that female students attract more help because they appear less confident with their work than male students:

> I think some of the male lecturers are more helpful to the girls than to the guys . . . but then I think it might be because the girls come across as less confident that the teachers want to help them more. (Elizabeth, Industrial Design and Technology student)

While some students described the extra help they unwittingly received as a result of the gender as patronizing, many women perceived this as positive. Nevertheless, this poses a particular problem because it indicates that women in engineering are seen as less capable than their male counterparts, which may be counterproductive in the long term. For example, while it may seem useful to get extra help, in the future it may result in women being

overlooked when promotion decisions are being made, if they are perceived by employers as requiring extra help and support to succeed in the workplace. In the more immediate term it may instil resentment in male colleagues and works to reinforce the idea that women are less capable in engineering among male engineering students:

> There's this one assistant in our department and he is known for helping girls out more than boys . . . the boys get a bit angry. (Maria, Industrial Design and Technology student)

The differential treatment of male and female students by staff went beyond the women students receiving more help, to sexist attitudes and humour, although this was generally accepted as 'joking' by women.

> One of our lecturers just makes women jokes, which are alright, they're not offensive, but you just get bored with them every lesson. (Paula, Mechanical Engineering student)

> Now and then they'll make obviously female jokes but I wouldn't say they necessarily treat you differently on purpose. (Amanda, Industrial Design and Technology student)

There was also a feeling among students that male lecturers felt uncomfortable with female students:

> Well some of [the male lecturers] struggle . . . they're quite happy to sit and chat to the guys but then find it very hard . . . they don't really know what to say [to the women students] it's almost as if you're not somebody who's normal. I mean there are extreme sides of it, there's one lecturer who completely could not hold down a conversation with a girl if he tried. (Eve, Civil Engineering student)

In addition, one student felt she was made particularly visible because of her gender and singled out when a lecturer complained to her personal tutor that she had missed a lecture. The student felt victimized because the lecturer failed to notice if male students were absent from class. Another student felt that when she complained that the male students she was working with were treating her unfairly, her female personal tutor failed to take her seriously:

> I told [my personal tutor] there were boys who were harassing me . . . they'd end up giving me the work . . . I told her about it and she was like, 'well, it'll pass' . . . she didn't even call them to talk to them. (Anna, Commercial Management and Quantity Surveying student)

A final factor described by women engineering students was the idea that universities may be 'playing a numbers game' by trying to increase the number of women on engineering courses to improve their image. There are

two key problems with this. While a drive to recruit more women is a positive step, alone this is unlikely to challenge or transform the masculine cultures and structures in engineering education and industry. Furthermore, as demonstrated in this research, it has the effect of making women doubt their own capability to do the work required:

> They were desperate to get me on the course because they needed to balance out their numbers. I've always felt like I don't know if I would have got on this course if I'd been a bloke . . . They didn't even look at my work, so they couldn't have known, and every bloke I've spoken to has a really vigorous interview. (Rebecca, Industrial Design and Technology student)

> One guy . . . said you are bound to get [a bursary] because at the end of the day they really need girls in engineering. And it really, really upset me. (Sophie, Mechanical Engineering student)

CONCLUSIONS AND RECOMMENDATIONS

To summarize, this chapter has explored women engineering students' experiences of UK higher education. It has investigated the pervading culture of engineering education and shown that women's experiences of this range from good to bad to ugly. Women's 'good' experiences included peer camaraderie, staff support and the industrial placement, while 'bad' experiences have been focused on structural aspects of HE, such as teaching and learning methods, and the 'ugly' (judged to be the most harmful to women students' commitment and career aspirations) has been associated with what others have called a masculine engineering culture, largely consisting of people's negative attitudes towards women in engineering.

It is clear from these interpretations that women's experiences of engineering education are contrasting and at times in conflict with one another, highlighting the fact that the 'good', the 'bad' and the 'ugly' experiences are in many ways mutually reinforcing. While the ugly experiences are the only area where women have faced obvious discrimination, the gendered culture of engineering and more subtle forms of discrimination are evident throughout. Peer camaraderie, for example, may demonstrate women's socialization into the masculine engineering culture, as this issue was often framed competitively, with students comparing their experiences to those of students on other courses. This is supported by Bennett et al. (1999), who maintained that women who seek a career in a male-dominated industry are socialized into its culture through the education system, and appear to actively seek that culture. This also corroborates West and Zimmerman's (1987) argument that both men and women 'do' gender, despite believing that their behaviour is gender-neutral. The apparent criticism of staff and

student relationships also makes it difficult to comprehend women's praise for staff support and peer camaraderie. However, it is important to note that women's experiences were categorized by the authors rather than the women themselves. In fact, women engineering students generally viewed the whole experience of engineering education positively in spite of admitting to the various structural and cultural problems identified above. This is further evidence of women's assimilation to the engineering culture and their, probably subconscious, knowledge that they are likely to suffer if they go against the unspoken cultural norms (Evetts, 1998). In this way, women engineers may help maintain gender inequality through their knowledge of what fits with the accepted organizational style (Gherardi, 1994).

In addition, the bad and ugly experiences, or the structural and cultural problems which women engineers experience in HE, are closely intertwined, with both impacting heavily on women's learning experiences. While the structural aspects of engineering education, namely the teaching and learning methods, or the formal curriculum, could be readily changed if desired (and possibly to the benefit of many male students), previous research has shown that re-evaluation of the curricula is slow to happen (Bagilhole and Goode, 1998). This is probably because the control of the curriculum is in the hands of men (Evans, 1995), who often believe that women need to change to accommodate industry, or learn to be discriminated against (Bagilhole and Goode, 1998). In other words, the structure or curriculum in engineering education is socially constructed, as Weiner (1994) has argued, and highlights assumptions about gender and knowledge. Bagilhole and Goode (1998) have also shown that the culture and dominant attitudes, or what they call the informal curriculum, is learnt by both male and female students, resulting in maintenance of the masculine ethos of engineering.

These arguments point to some of the difficulties of transforming the engineering culture to ensure the engineering professions are a place where women can not only survive, but also thrive. Even change in areas that could be achieved, such as in teaching and learning methods, may be difficult due to resistance from those who uphold the masculine culture of engineering. However, it might also be argued that improved teaching and learning methods could stimulate cultural change.

In conclusion, this chapter has supported and elaborated the extant knowledge on women in engineering education. However, it has also offered a new classification of the structural and cultural influences impacting upon women's experiences (the 'good', the 'bad' and the 'ugly'). At the same time, it is evident from the findings that any progress towards change requires a multi-institutional approach aimed at enhancing the 'good', addressing the 'bad', and precluding the 'ugly'. While such an approach

should build on the positive aspects identified by women, such as personal tutor support and the industrial placement, responsibility for implementing structural change should be taken by professional engineering bodies, such as the UK Engineering Council, and cultural change by HE employers, trade unions and student unions, among others. As Sagebiel (2003) has argued, the success of such important and much-needed changes are also likely to be dependent on promoting the benefits they could have for *all* students, not just women.

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