

Challenging Knowledge, Sex and Power

Gender, work and engineering

**Julie E. Mills,
Suzanne Franzway, Judith Gill
and Rhonda Sharp**



Routledge IAFPE Advances in Feminist Economics

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CHALLENGING KNOWLEDGE, SEX AND POWER

Women in the developed world expect to work in the labour force over the course of their lives. On finishing school, more girls are entering universities and undertaking professional training for careers than ever before. Males and females enter many high-status professions in roughly equal numbers. However, engineering stands out as a profession that remains obstinately male dominated. Despite efforts to change, little progress has been made in attracting and retaining women in engineering.

This book analyses the outcomes of a decade-long investigation into this phenomenon, framed by two questions: Why are there so few women in engineering? And why is this so difficult to change? The study includes data from two major surveys, accounts from female engineers in a range of locations and engineering fields and case studies of three large engineering corporations. The authors explore the history and politics of several organizations related to women in engineering, and conclude with an analysis of a range of campaigns that have been waged to address the matter of women's minority status in engineering.

Challenging Knowledge, Sex and Power will be of great interest to students of the sociology of work and of feminist economics, and is also relevant to researchers in women's studies and engineering education.

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Routledge IAFFE Advances in Feminist Economics

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
APESMA	Association of Professional Engineers, Scientists and Managers Australia
BBC	British Broadcasting Corporation
BP	British Petroleum
CAWMSET	Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (US)
CCWESTT	Canadian Coalition of Women in Engineering, Science, Trades and Technology
CE	Consulting Engineers (pseudonym for case study firm)
CPD	Continuing Professional Development
CU	Corporatized Utility (pseudonym for case study firm)
DEEWR	Department of Education, Employment and Workplace Relations (Australia)
DEST	Department of Education, Science and Training (Australia)
EA	Engineers Australia
EAW	Electrical Association for Women (UK)
EEO	Equal Employment Opportunity (Australia)
EOC	Equal Opportunities Commission (UK)
EOWA	Equal Opportunity in the Workplace Agency (Australia)
EPF	École Polytechnique Féminine (France)
ERA	Equal Rights Amendment (US)
ETAN	European Technology Assessment Network
IBM	International Business Machines
ICWES	International Conference of Women Engineers and Scientists
IET	Institution of Engineering and Technology (UK)

INWES	International Network of Women Engineers and Scientists
IPENZ	Institution of Professional Engineers New Zealand
LGBT	Lesbian, gay, bisexual and transgender
MP	Mineral Processing (pseudonym for case study firm)
NSB	National Science Board (US)
NSF	National Science Foundation (US)
OHSW	Occupational health, safety and welfare
OECD	Organisation for Economic Co-operation and Development
SA WIE	South Australian Women in Engineering
SET	Science, engineering and technology
STEM	Science, technology, engineering and mathematics
SWE	Society of Women Engineers (US)
UK	United Kingdom
UKRC	UK Resource Centre for Women in Science, Engineering and Technology
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISON	A large public sector trade union in the United Kingdom
US	United States
WES	Women's Engineering Society (UK)
WIE	Women in Engineering
WIENC	Women in Engineering National Committee, Engineers Australia
WISE	Women into Science and Engineering (UK)
WOMENG	Women in Engineering (EU)

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1

WHY SO FEW WOMEN ENGINEERS?

Bev's story

Bev was the only woman in her year when she studied engineering in Australia in the 1970s. After graduation she was employed for nearly 30 years by a large mineral resources company with global interests, rising to principal civil engineer and a section leader of the company's engineering technology group. In Bev's view, a successful engineer combines thorough technical competencies with good people skills, but she strongly believed that the male-dominated engineering profession fuels an uncomfortable workplace culture for women engineers. Although in her early career she did not hold this view, in her later years she had come to regard this perception as a major survival strategy. As a young professional, she dealt with prejudice and discrimination with the motto, 'if you don't look for it, you don't see it . . . you don't find it'. However, with ongoing experience and growing confidence in her own professional standing she felt an urgent need to name the many forms of negativity to which women engineers were continually exposed. While some women engineers blind themselves to such discrimination, Bev recognized that 'it certainly is there, it was there then and it certainly is still there now'.

Introduction

Engineering is a male stronghold with enrolment and workforce participation of women being less than 20 per cent of the total in many parts of the world (Mills, Ayre and Gill 2010). Forty years ago, the second-wave women's movement was credited with producing a highly charged environment in which women demanded the right to pursue education and careers from which they had been previously precluded. A wave of activity accompanied the uptake of what were known as 'non-traditional' careers in which women enrolled in trade courses, demanded opportunities to train to be airline pilots, called for increased openings in the military establishment and the right to equal pay for equal work. At a global

2 Why so few women engineers?

level, women's right to vote had been established in most countries and more and more women around the world joined the paid workforce. In the last decades of the twentieth century young women were increasingly likely to expect to be in paid work for most of their adult life. Higher education and the professions also were claimed by increasing numbers of female entrants. This did not herald immediate change in the gendered constitution of the professions, senior levels of which continued to be dominated by males. However, the likelihood of a critical mass of female lawyers and doctors at the cutting edge becomes an increasingly pronounced feature of these fields. Not surprisingly, differences were seen to exist between fields in terms of women's engagement and some areas are still slower to accommodate women; for example, fewer women at top levels of corporate management, in government and controlling finance. Slowest of all was the discipline of engineering, which stands out as the intransigent traditionalist in terms of women's minority status. Certainly engineering enrolment numbers and workforce participation continues to be male dominated in many parts of the world (Mills, Ayre and Gill 2010).

Bev was an engineer, a committed feminist and passionate about her chosen profession. She had devoted large amounts of time and energy to making engineering more attractive to women and to working for positive change for women from the inside. As she developed her own understanding of the ways in which the male-dominated world of engineering impacted on the small minority of women members, Bev strove to recruit men and women engineers to work together for a more inclusive professional experience. Sadly, Bev did not live to see the results of our series of studies, to which she was an inspirational contributor. We continue to refer to her experiences as a link between her insightful observations of 'how it is right now' and the longer story of our joint research enterprise.

Like Bev, we take a feminist perspective on the persistent problem of the male dominance of engineering. We ask two questions: Why so few women engineers? And why has engineering been so resistant to change? These questions are central to this book and to the studies on which it is based. Our broad argument is based on feminist analyses of our research on the experiences of engineers, their workplace cultures and their campaigns for gender equality. Drawing on this extensive data, we propose that knowledge, sex and power are at stake in any effort to understand and to challenge gender inequity in engineering.

Women in paid work in the twentieth century

While Bev's story provides an acutely perceptive account of her experience as a member of a minority in a male-dominated profession in late twentieth-century Australia, it is certainly not unique. Nor is it historically or culturally specific. By 2012, rapid social and economic changes across the world have seen women participate in the paid workforce in greater numbers, and in a wider range of occupations and positions, than ever before. Yet women remain seriously disadvantaged on many equity measures, and the gains from decades of gender-equity

policies and campaigns in many countries have been slim. Engineering is an exemplary case as it continues to be one of the most male-dominated professions around the world. There are few women at entry levels of the profession, and even fewer at senior management levels. In describing her lengthy career, Bev refers to her changing knowledge about workplace gender relations, the impact of women's family roles and the kinds of resistance she met from both men and women. Her story points to the significance of knowledge, sex and power in understanding and changing male-dominated work.

Women's increased participation in paid work is only part of the story. The conditions under which they participate are also critical. Documenting, understanding and changing these conditions comprises a challenge for feminist scholars, workplace activists and policy makers. In engineering, both participation and the conditions of work are problematic for women. Unlike similar professions such as medicine or law, where at least the participation rates have improved, in engineering the number of women remains very low, and their knowledge and power is almost invisible.

In the majority of countries women's participation in employment has been rising steadily since the middle of the twentieth century, but significant variations exist between countries. The proportion of women aged 15–64 years engaging in paid work in Organisation for Economic Co-operation and Development (OECD) countries on average had increased to 45 per cent by 1970, rising to 58 per cent by 2008 (OECD Social Policy Division 2010: 7). The large-scale entry of women into paid work has brought with it marked changes in everyday life, institutions, policies and production capacities. Some commentators stress the benefits for the economy. In 2006, *The Economist* coined the term 'womenomics' to argue that the main driving force for growth in the industrialized world in the last two decades has been the significant increase in female employment, exhorting the world to 'Forget China, India and the internet, economic growth is driven by women' (*The Economist* 2006: 14). However, feminist analyses raise concerns about the gendered patterns of labour market participation. These concerns include the segregation of men and women into 'masculine' and 'feminine' industries and occupations, the concentration of women and girls into part-time, casual and unregulated jobs and the greater likelihood of women having broken workforce patterns that have negative effects over their working lives.

The potential for participation in paid work to provide financial independence, status and bargaining power in the home and wider society has fallen short for many groups of women. The basis on which the majority of women engage in paid work is different from that of most men, with women being relatively disadvantaged compared with male peers. In many countries, female labour-force participation remains lower than men's and gender gaps exist in terms of pay, career pathways, leave entitlements, training, hours of work, job security, job turnover and retention, occupational health and safety, unemployment, underutilization and retirement pensions. However, paid work is far from a homogenous experience among men or women. For example, the experience of work for white, educated

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women from post-industrial countries has different meanings than it does for poor women in industrializing countries.

Feminist analysts argue that gender differences shape men's and women's provision of paid labour. However, such differences are not neutral in terms of power, status, income and workload. Across the world, women are disproportionately responsible for all aspects of social reproduction, including largely unpaid care of the young, old and disabled, informal learning and subsistence. All of these features of unpaid labour, along with domestic activities, enable others to participate in paid work. Women's work is thus central to the functioning and reproduction of a society and an economy. However, this traditional division of labour in the home leaves most women with less time to spend in paid work and/or fewer options about the type of paid work they may undertake during their working life. Thus women's responsibility for unpaid work and family life has significant and enduring implications for gender equity in paid work.

The unequal effects of gender differences in paid work also reflect significant policy variations across countries. The policies of the state can have an important bearing on the terms on which women and men engage in paid work and social reproduction. Policies on employment, industrial relations, unionization, taxation, child care, welfare and anti-discrimination can provide economic and other incentives or disincentives and impact on barriers and capacities to participate in paid work. Thus questions about women's inequality and work relate to the entire social organization and transcend the simple equation of equal money for equal time.

The intractability of gender inequity in paid work matters for a number of reasons. That men and women should have equitable access and opportunity in relation to work as a matter of fairness and social justice is a long-established norm at national and international levels. A lack of fairness can have adverse economic effects; economists regard discrimination in the labour market as costly and as an indication that markets are not working efficiently. Equal employment opportunities are jeopardized when women miss out on career opportunities in high status, satisfying and well-paid work, such as engineering.

While considerable debate exists within the field, there is broad agreement that gender equity in work is a stubborn problem, constituted by complex relations of gender, but also by power and politics, and by the interplay of knowledge and practice. Attempts to resolve this problem are necessarily political and involve challenges to power as well as to understanding, identities and knowledge. In this book, we develop an approach that challenges gender, power and knowledge in order to yield gains for gender equity through a focus on a specific field of paid work: engineering. Engineering continues to be a male-dominated field in which women's participation rates and conditions remain inequitable. Thus engineering serves as a representative example of the challenges faced in achieving gender equity in general, and in male-dominated occupations in particular. Within the frame of the problem, this book asks critical questions about women's participation and their conditions.

Although such questions serve to clarify the aims of the overall project, they invite an approach to gender that constructs a men/women binary, which can itself

be counter-productive. So it is important to say at the outset that we do not regard gender as fixed or unproblematic, but rather as a construct grounded in relational and multidimensional interactions. As Raewyn Connell argues, gender embraces 'economic relations, power relations, affective relations and symbolic relations, and operating simultaneously at intrapersonal, interpersonal, institutional and society-wide levels' (2011: 3). Such relations are dynamic and contested, and always political – changing through time in a continual and dynamic process of sexual politics. Understanding gender in these terms, we propose a new theoretical framework for analysing the problem of gender inequity and its persistence in engineering. This framework emerged from our extensive range of data collected from a decade long series of studies. We now turn to an overview of the field of engineering.

Engineering work

Historically, engineers were essentially 'craftsmen' (sic) who learned on the job under an apprenticeship system. Engineering design – the process that resulted in the construction of Roman aqueducts and water-supply systems, and monumental structures such as cathedrals – was a process of trial and error in which knowledge was passed down through guilds and societies. The word *engineer* is derived from the Latin *ingeniator*, meaning someone who is ingenious. The designation of engineering as a profession, and the development of a formal education system for this purpose, had its origins in the late eighteenth century during the Industrial Revolution. The first university-type courses were developed in France in the early nineteenth century, under the auspices of the French government, and other countries followed suit shortly afterwards (Lundgreen 1990). Until the early to mid-1900s these programmes retained a strong practice-based focus. However, particularly post-Second World War, the engineering profession became increasingly mathematics and science-based and it is now considered to be a 'white collar' profession (Seely 1999).

Engineering plays an important role in tackling the challenges of the twenty-first century, including globalization, population growth, climate change, inequality and sustainable development. Engineering is a universal presence in both poor and developed societies. It responds to fundamental human needs such as potable water, serviceable roads and is centrally involved in the production of complex machinery and long-lasting buildings, along with food and fuels. The engineering profession is also responsible for the design, construction and maintenance of highly sophisticated communication technologies, innovative biomedical devices and instrumentation, massive structures such as bridges and tunnels on the one hand, and microscopic nanotechnology applications in medicine and manufacturing on the other. There is almost no aspect of modern life that is not significantly impacted by engineering advances. Of course, this story is not always one of straightforward progress. There have been some spectacular failures and environmental disasters that can be laid at the door of the engineering profession, some of

which have had negative impacts in developing countries. Clearly engineering is a profession that has had, and will continue to have, a huge influence on modern society. However, as a profession, engineering continues to be not well understood despite its broad reach in terms of social and theoretical applications.

Engineering: constructed as masculine?

Across the English-speaking world the profession of engineering has been constructed as a masculine form of work. Its images pertain to large-scale machinery and construction in which men engineers are positioned as struggling against the forces of the natural world to wrest metals from the earth, to cross natural boundaries of water and air, to combat gravity in producing high-rise buildings and to redefine human possibilities in terms of travel and communication. In reality, engineering requires not only technical knowledge and capacities, but also extensive communication skills and the ability to manage both people and resources. Engineers may rightly complain that the nature of their work is often misunderstood, but it is certainly a highly respected and well-paid profession in most countries. However, in this book the male dominance of engineering, its practices and effects, is being radically challenged.

Despite widespread publicity and recruitment campaigns in recent decades, the profession of engineering has made little progress towards achieving gender parity and remains one of the most male-dominated professions in the world. Fifty years ago, the vast majority of professions were male dominated – medicine, law, economics and so on. But while these professions have by no means achieved equity for women, they have at least significantly increased the proportion of their members who are women. In the same timeframe, the engineering profession has increased its proportion of women from basically none to seven per cent in the UK (Kirkup, Zalevski, Maruyama and Batool 2010), 11 per cent in Australia and the US (Australian Bureau of Statistics [ABS] 2009; National Science Foundation [NSF] 2009), and less than 20 per cent of the professional workforce in the majority of the world.

Not surprisingly, the age profile of women engineers is much younger than men engineers in most countries, since the majority have gained their qualifications within the last 20 years. For example, in Australia in 2006, 48 per cent of women engineers were aged under 35 years and 77 per cent under 45 years (Kaspura 2011). However, 40.8 per cent of the engineering labour force was aged 45 years and over, with 16.2 per cent aged 55 years and over, hence nearly all of these individuals were men. In addition, this age discrepancy is further exacerbated by the loss of many women to the engineering profession in their thirties, which we discuss later.

The term 'engineer' is often somewhat loosely applied and widely defined. This book focuses on professional engineers. While the exact education requirements can vary from country to country, the requirement for admission to the engineering profession is usually four to five years of university education to receive a Bachelor of Engineering degree and ongoing continuing professional development