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# The Culture of Engineering Education and its Interaction with Gender: A Case Study of a New Zealand University

Janett Elizabeth Godfrey

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# Abstract

This study focused on the culture of engineering education, a culture which has been characterised internationally as reflecting masculine attitudes, values and norms of behaviour, thereby reinforcing the current under-representation of women. The goal of the study was to define the dimensions of the culture and the associated processes of enculturation, highlighting the interaction of these with gender. Following a review of relevant literature, research questions were formulated. These were addressed through an interpretive case study undertaken at a multidisciplinary School of Engineering in a New Zealand university. The study used predominantly ethnographic methods of data collection.

To guide the analysis, a model was developed based on Schein's (1985) theoretical framework. The first level of the model involved the identification of observable manifestations of the culture (grouped as Artefacts, Practices and Behaviours). At the second level, shared values and cultural norms were induced from the observable manifestations. At the third level, the essence of the engineering education culture was distilled from these values and norms, in the form of seven cultural dimensions. At each level of the analysis the explicit and tacit processes of enculturation, especially in relation to gender, were considered.

This research exposed the masculinity of the basic beliefs and assumptions at the core of the disciplinary culture, revealing the source of enduring cultural norms and their manifestations in behaviours and practices. Diverse forms of masculinity were evident, especially within sub-disciplinary subcultures, but all were constructed in opposition to perceptions of femininity.

Participants in the study (whether male, female, students or staff) perceived women in engineering as different, not only to men, but to other women. The women students appeared to construct for themselves a dual identity. They selectively incorporated in this identity both stereotypically masculine and stereotypically feminine qualities, in

accordance with their perceptions of simultaneously "doing woman" and "doing engineer".

The theoretical significance of this study lies in its provision of an accessible framework for cultural analysis by engineering educators and equity advocates. The framework facilitates exposure of the source of observable behaviours and practices in the unconsciously held beliefs and assumptions at the core of the culture of an institution or discipline. The practical significance lies in its potential to provide a base for developing strategies for cultural change advantageous to the participation of women. The findings of this thesis strongly suggest that such strategies must focus on disrupting the current dualities in language and discourse which implicitly construct women as different, deficient and therefore disadvantaged in engineering education. In particular strategies need to expose behaviours and practices to critical reflection by staff and students, making explicit the values and assumptions which underpin them. Further, while maintaining those features which are the strength of engineering education, there is a need to also include and value ways of knowing and learning styles from outside the current disciplinary and gendered boundaries.

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# Chapter 1

## Introduction and Overview

> *To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male.*
> *McIlwee & Robinson, 1992, p.21*

## 1.1 General background and purpose

The male dominance of the engineering profession and engineering education was unquestioned for much of the twentieth century. It was not until the 1980s and 1990s that concern at the lack of participation by women in engineering education began to arise. Initially, an increase in participation by women was seen as desirable for two reasons: because of a perceived potential shortage of engineers and need for a larger pool of qualified technologists (Hornig, 1984), and to satisfy the desire for equity and social justice as women increasingly entered higher education and the workforce. The rapid growth of women in engineering recruitment initiatives during these decades was a response to this concern (Cronin, Foster & Lister, 1999; Truxal, 1983).

Although national and institutional needs and gender equity still provide the motivating force behind funding for many women in engineering initiatives, there is also an increasing recognition that women may bring perspectives and experiences to the engineering profession which are different to those of men, and that diversity carries with it some benefits. In Australia, the Williams Review (1988) described the engineering profession as "impoverished" by its failure to attract females. This was one of the earliest statements that women might have value as engineers, not just to restore falling numbers, but in their own right. In Britain, the government commissioned report (Committee on Women in Science, 1993) identified a "rising tide" of awareness that the loss of ability and skills caused by gender bias was neither acceptable nor in the national interest.

The Australian Review of Engineering Education (IEAust, 1996) went further, stating that "[T]he culture and practice of engineering will be transformed through the much greater participation of women" (IEAust, 1996, p. 14). This review recognised that, although engineering had achieved great technological advances, there was a lack of awareness within the profession of environmental and social issues in the community and wider society. The Review identified that engineering education needed an inclusive culture to attract a more diverse range of students that would adequately represent and react to these issues in ways that reflect the values, beliefs and attitudes of the wider society. In particular, it stated that the engineering profession (and by implication engineering education), numerically dominated in Australia by white middle class males, could be seen to reflect masculine attitudes, values and norms of behaviour.

The comments from these Reviews resonated with my accumulated experience from over ten years of recruiting and supporting women into and within engineering education. These years provided me with many rewarding and inspiring experiences, but also with unsettling contradictions and an increasing sense of frustration at the slow pace of change.

Although there have been some improvements, the under-representation of women in engineering education has continued despite over twenty years of initiatives internationally. The level of female participation in engineering education continues to be considerably lower than in other tertiary areas of study that had once been traditionally regarded as male domains, such as medicine, law and veterinary science. The primary problem that my study explores, is therefore, the under-representation of women in engineering education.

### 1.1.1 My perspective

As intimated above, a basic assumption in my study is that the increased participation of women in engineering education and ultimately in the profession is desirable. A large body of literature over the last 20 years has identified and discussed the factors that might contribute to the continued under-representation by women in engineering and engineering education. Ambrose, Lazarus and Nair (1998) commented “there are no universal constants to describe the ways in which women find and keep their place in science and engineering” (p.366) and as the literature that I have reviewed in Chapter 2 confirms, there are no simple or complete answers to the question of why women are so under-represented in engineering in Western society.

My observations and reading over a number of years have identified strong suggestions that "what goes on" at the tertiary education level, in terms of subject content and context, social behaviours, and teaching and learning practices, has contributed to the under-representation of women. Several authors (McIlwee & Robinson, 1992; Roberts & Lewis, 1996; Seymour & Hewitt, 1997) extended the discourse further to argue that the "culture" of engineering education perpetuates the under-representation of women at the level of both recruitment and retention into the profession. If the culture of engineering education is indeed a major deterrent to the participation of women, then arguably, an analysis of that culture is fundamental to addressing the issues surrounding the participation of women in engineering.

I have centred my study, therefore, around the basic hypotheses that firstly, a relationship exists between the culture of engineering education and the under-representation of women, and secondly, that this culture needs analysis and definition because its influence is far-reaching, for females, for males, and ultimately for the profession and the community. I chose to explore these hypotheses through a case study at the University of Auckland over the period 1996 to 2001.

### 1.1.2 Specific context

#### *1.1.2.1 The case study site*

A brief background to some of the characteristics of the institution chosen for my case study is appropriate at this time, although I shall describe it further in Chapters 3 and 4. At the outset of my study the University of Auckland (known hereafter as U of A) School of Engineering was one of only three universities in New Zealand able to graduate professionally accredited engineers. In 1998 there were 1344 undergraduate students associated with the five departments: Chemical and Materials Engineering, Civil and Resource Engineering, Electrical and Electronic Engineering, Engineering Science and Mechanical Engineering. Student numbers have grown to 2010 in 2003.

The Bachelor of Engineering degree is a four-year degree, awarded with Honours. Prior to 1996, the first year was predominantly science courses with only one course, Engineering Mechanics and Design, taught in-house. Since 1996 all first year courses have been engineering oriented and taught by engineering staff except for one elective course of the student's choice, which may be a first year course from the Arts, Science or Commerce faculties.

The School of Engineering was originally founded in 1923. It was located for 20 years (1948-1969) 40km south of the main campus in central Auckland at an ex-Air Force base in rural farmland with on-site accommodation and fairly rudimentary facilities. The inventive pranks, raids on the main campus, and rituals of initiation of the all male student body are the stuff of legend. At least ten of the staff teaching at the time of my study had been students at the rural campus and the sense of being a School rather than a series of engineering departments has been seen to come from those years (Bassett, 1969). When the School relocated back onto the city campus (in 1969), to a large new building, women started to enrol and the first New Zealand-born woman graduated in 1974. The number of women did not significantly increase until the 1980s when they rose from 2.5% in 1980 to a maximum of 10.5% in 1989.

The School of Engineering recognised the under-representation of women as far back as 1982, when the Dean's Message in the prospectus that "what we should like to see is a substantial increase in the number of girls selecting engineering" made that explicit. After informal volunteer-based efforts to raise the profile of engineering with young women, the Chair of the Women in Engineering Committee, supported by the Dean of Engineering and Dean of Science, obtained government funding which resulted in the full time appointment of a Liaison Officer for Women in Physical Sciences and Engineering in 1989. This was the first position of its kind at a tertiary institution in New Zealand, and after government funding ended in 1991, the central administration of the university funded it as a permanent position. I held that position from 1989 to 2000. My appointment, combined with government and community initiatives, has been seen (Stonyer, 2001) to have influenced the climb in women's participation to a level which has been virtually stable at 19-20% since 1995, displaying (as seen in Chapter 8) significant subdisciplinary variation.

#### *1.1.2.2 Personal background*

I came to this investigation with a background which included seven years of graduate study and lecturing in Chemistry, twelve years of high school teaching in Mathematics, Chemistry and Computer Studies, followed by over ten years working as the Liaison Officer for Women in Science and Engineering. As an academic survivor of the positivist systems of mathematics and science, I am an enthusiastic and sometimes passionate advocate for the opportunities in education and employment offered by the fields of science and engineering.

I saw contradictions, however, as I sought to attract and support young women into the profession of engineering. The attraction of a profession that enabled its graduates to "make a difference" and, in the process of their education, achieve a high degree of professional and personal growth, was offset for me by perplexing and demoralising issues that arose from time to time. Outwardly female students with whom I was in regular contact achieved well academically, reported enjoying their university years, and often vehemently denied any notion of their “difference” on a basis of gender. Yet I found evidence of a perception of the need to “fit in”, acceptance and adjustment to “the engineering way”, denial of the feminine – anything soft or emotional, and occasional “war stories” of discrimination and injustice.

I noted the international trend of a plateauing of female participation in engineering education at levels between 10 and 20%, despite many interventions and initiatives by governments and universities (Committee on Women in Science, 1993; CuWaT, 1998; Lewis & Harris, 1995; Vetter, 1996). I perceived that participation at my university, the University of Auckland, was following that international trend. A number of questions arose for me, including:

- Why did female participation plateau at 20%?; and
- Was there a point at which targeted recruitment activities (Farmer, Godfrey & McCowan, 1991; Godfrey, 1997) could stop?

I was particularly concerned with the naming of “women in engineering” initiatives which not only appeared to locate the “problem” with women but constructed women as a homogeneous group. I saw the implied homogeneity of “women” at odds with my own observations and the then current research that acknowledged the diversity and ongoing construction of gendered identities. Eveline’s (1994) perspective of shifting the discourse from one of viewing women as disadvantaged to uncovering the position of advantage which appeared to be a norm for men was influential in my decision to pursue this research.

In choosing to study culture and use qualitative methodologies, I recognised that I was leaving the “safety” of my positivist background with its assumptions of objectivity and lack of bias. I was, however, comfortable, in the sense that my long exposure to the research site, and the checks for validity and trustworthiness built into the research design (outlined in Chapter 3) have ensured that my study satisfies the tenets of rigorous research. To forefront my acknowledgement of the subjectivity of this research I have written in the first person.

### 1.1.3 Close links – New Zealand and Australia

Although this case study was conducted at the School of Engineering of a New Zealand university, much of the literature and practice referred to within this thesis is from the Australian higher education sector. As the only person employed in a Women in Science and Engineering capacity in New Zealand for the last ten years, close contact with colleagues through the Australasian Women in Engineering fora and the Australasian Association for Engineering Education conferences has been my source of theoretical and practical collaboration. With more than 30 institutions offering engineering degrees, combined with similarities in our national cultures, Australia has long been seen as an appropriate partner for New Zealand in the interchange of research, innovation and strategies within engineering education. In educational research and initiatives, Australia has led New Zealand (which, for example, has no equivalent of the federally funded grants available to higher education for educational innovation). Although the professional association IPENZ moderates professional courses and provides a forum for inter-institutional discussion, no comprehensive reviews such as the Australian 1988 Review of the

Discipline of Engineering (Williams, 1988) and the 1996 Review of Engineering Education (IEAust, 1996) have been produced. Research within New Zealand relating to women in engineering has also been limited (Buckett, 1997; Ditcher, 1998; Dunlop, 1991; Stonyer, 1996) although reports and papers of a more anecdotal style have appeared (Elder, 1988; Kivell, 1998; Shaw, 1993).

## 1.2 Purpose and content of this chapter

Following this brief introduction to the purpose and context of my study I will present, in the following sections of this chapter, the rationale behind the formulation of my research questions, with a synopsis of the limitations in the current initiatives and theorising around the participation of women in engineering. I follow this with an outline of the theoretical framework I have used as a starting point, my choice of research design and methodology, and a summary of my analysis and findings. In conclusion, I discuss the theoretical and practical significance of my study, followed by an overview of the structure of my thesis.

## 1.3 Rationale

My study builds on a substantial body of research in the fields of engineering education, culture, gender and women's participation in science and engineering. This research, a selection of which is outlined in Chapter 2, has been the foundation for the many of the strategies and interventions that have contributed to the growth in women's participation in engineering education over the last two decades. In this section, however, I identify limitations in practice and theorising which indicated to me a need to move beyond the "current" in the provision of more productive theoretical bases for action.

### 1.3.1 The limitations of current initiatives as solution to the problem of under-representation

From the mid-1980s, Australian and New Zealand higher education institutions increasingly promoted engineering to females using strategies that had appeared to bring positive results internationally. Liberal feminist philosophy had suggested that, if women are given equal access to the education system, they could do what men do and have what men have. This thinking was responsible for a plethora of interventions to raise the awareness of young women to the rewarding career opportunities of engineering and to support women in non-traditional courses within tertiary institutions. These are well documented in the international literature (Davis & Rosser, 1996; Learmont & Lindley, 1993) and the proceedings of GASAT (Gender and Science and Technology) conferences (reviewed in Vlaeminke, Vlaeminke, Comber & Harding, 1997). The main goals of these interventions were to increase participation rates of women in engineering and to encourage retention of women within engineering. A variety of strategies have been reported, but by far the greater proportion involved the promotion of engineering as a career for women. Using videos, books, speaker programs and seminars of length from one afternoon to several days, the dominant target group was school students in Years 10 – 12.

As I will discuss in more detail in Chapter 2, a shift in focus occurred in the 1990s for many Women in Engineering initiatives in Australia and internationally. Byrne's work in the early 1980s (Byrne, 1993), as part of the University of Queensland Women in Science and Technology in Australia project, was influential in shifting the thinking from "changing the women" (which implied the problem was located with women's lack of experience, schooling and awareness of career opportunities) to "changing the system" (Lewis, 1993).

Opportunities for systemic change were seen as lying in recognition that the content, teaching methods and styles, and criteria for success in engineering were not only male-defined, but also that the knowledge itself reflected a bias towards a male cognitive style (Cronin & Roger, 1999; McIlwee & Robinson, 1992; Roberts & Lewis, 1996). Curricula and teaching guidelines labelled "gender inclusive" were produced in Australia (Moxham & Roberts, 1995), the USA (NECUSE, 1996) and the UK (CuWaT, 1998), and several Australian universities have implemented these strategies (Ayre, Nafalski, & Priest, 1998; Whelan & Subic, 1996). Despite this range of initiatives the national statistics for Australia (see Appendix 1) and New Zealand (see Appendix 2) indicate that few institutions have reached the level of participation (15-20%) at which Lantz (1982), twenty years earlier, suggested there would be no further need for recruitment/retention programs and initiatives. From a cultural perspective, my view was that changes framed by minor (sometimes marginal) curriculum and pedagogy reforms, whilst a positive step, would have short term effects only, unless the underlying values, beliefs and attitudes behind those changes were understood and assimilated into the culture. In other words – more research was needed.

The large volume of research investigating classroom and laboratory dynamics and gender biases in curriculum and assessment at secondary school level (e.g. Kahle, 1988; Parker & Rennie, 1998; Parker, Rennie & Harding, 1995; Sjoberg & Imsen, 1988) has not been matched at the tertiary level (Lewis, 1995). Exceptions were Hacker in the early 1980s (Hacker, 1985) and Tonso (1996a, 1996b) who have provided studies, utilising participant observation, to examine more closely the dynamics of gender relationships in engineering classrooms. There is, however, a considerable weight of qualitative evidence, based on interviews with current and past graduates, that female students may experience the learning environment as a "chilly climate" (Bergvall, Sorby & Worthern, 1994; Hall & Sandler, 1982; Lewis, 1995).

The limitations of initiatives to increase the participation of women in engineering education have been viewed as:

- The majority of institutions continue to visualise the problem of under-representation as one of access, locating the problem outside of the institution in the realms of the secondary education system, or women's interests (Cronin & Roger, 1999). Rather than envisaging a need for change within the institution, women are encouraged to enter engineering "but leave the traditions and culture intact" (Cobbin, 1995);
- the administration of women in engineering or equity projects is often located outside of engineering faculties, and the "women in engineering" staff lack power and influence (Lewis, 1995);
- women in engineering projects are often limited term projects funded by "soft" money or corporate sponsorship (Chubin & Malcolm, 1996; Stonyer, 2001).

A strong rationale for my study was Cobbin's (1995) recognition that the culture of engineering education was largely untouched by current initiatives.

### 1.3.2 Lack of clear definition of concept of culture in the context of engineering education

There appear to be two major limitations in the theorising around the culture of engineering education. The first is the lack of clear definition of what culture means in this context.

Social scientists are familiar with the use of the concept of culture. This familiarity enables them to comfortably assert (CuWaT, 1998; McIlwee & Robinson, 1992) that "values, beliefs and assumptions" underpin and guide behaviours and practices that are seen as cultural norms. Engineers, who have been seen as undervaluing or dismissing the skills of qualitative research (Thomas, 1990) appear less likely to have common understandings of the concept of culture. Even the 1996 Australian Review of Engineering Education (IEAust, 1996) which highlighted a need to recognise "the differences between the values that underpin the existing culture and the espoused values to which it aspires" (p. 21) did not make clear what those current underlying values were. One example of this lack of clarification is the heavy workload that engineering students internationally speak of and which is said to be part of "the culture" (IEAust, 1996; Lewis, McLean, Copeland & Lintern, 1998; Seymour & Hewitt, 1997). I would argue that an understanding of what value, belief or assumption was the source of this behavioural norm might help answer questions such as: Is the heavy workload essential to engineering education and why is it valued?

I propose that a conceptual framework accessible to engineering educators is needed for understanding of the concept of "culture" and its relationship to observable behaviours and practices. I see the identification of the dimensions of the current culture and the processes by which that culture is sustained, as a sound basis for change.

### 1.3.3 Lack of research into possible subcultures within the culture of engineering education

The second limitation in theoretical discussions of the culture of engineering education appeared to be the assumption of a unified homogeneous culture with a lack of research into national, institutional and discipline specific subcultures within engineering education.

In Australia, both Byrne (1993), and later Cobbin (1995), in her study of women's participation in non-traditional fields of study at the undergraduate level of higher education 1989-1993, observed that some institutions persistently attracted higher female participation than others. This higher participation appeared unrelated to specific promotional initiatives. Illustrating this trend, Cobbin's (1995) data showed participation in a single sub-discipline such as Civil Engineering ranging from 7-27% across different institutions in Australia in 1993 (see also Appendix 1, Table A1.2 for an example of 2000 data).

The sub-disciplinary variation in participation in Australian enrolment data (see Table A1.1 in Appendix 1), illustrates that attracting women continues to be less of a problem in Chemical Engineering than it is in other sub-disciplines, particularly Mechanical Engineering.

Cobbin's Australian study, which split participation by sub-discipline and by institution, suggested that women's representation in the various engineering fields of study tended to be:

- higher in relatively small fields of study rather than the large mainstream groupings, therefore providing fewer graduates in spite of increasing representation;
- higher at the established universities or campuses compared with newer institutions where comparable courses were available;
- lower for courses perceived as less prestigious ( i.e. lower entry requirements) in the same discipline area;
- lower in sub-degree courses than degree courses (in the same discipline area);

- lower in computer oriented engineering courses with a hard core computer programming emphasis;
- higher in courses with chemical and life science orientations (e.g. chemical, environmental);
- higher in some double degrees that permit a broadening of studies (i.e. arts or science) rather than more of the same thing (i.e. computer science).

A project report commissioned by the European Union similarly commented that national, institutional and discipline specific differences appeared highly likely to provide a complex picture, where the culture would be influenced by the nature and content of a discipline and how it was practised in the "real world", as well as influenced and reinforced by how staff and students played their roles (CuWaT, 1998).

For me the question kept arising: do we just accept the status quo of disciplinary differences in participation, or do we seek out why these trends persist? I argue that until we know why they persist we cannot effect change. My premise in this study is that clarification of the interaction of gender with these subcultures, indicating why women avoid some disciplines and gravitate towards others, has the potential to make visible the cultural features that either aid or hinder the participation and performance of women.

### 1.3.4 Limitations of previous research in the theorising of how "gender" interacts with the culture of engineering education

My wide-ranging reading indicated to me that the majority of Women in Engineering initiatives were based on theorising from the extensive literature of women and science. At both the theoretical and practical project level, science, engineering and technology (Cronin & Roger, 1999) or technology, engineering and computing (CuWaT, 1998) have been "lumped" together. By contrast, the annual Women in Engineering Program Advocates Network (WEPAN – USA) and Australasian Women in Engineering conferences have provided opportunities for a focus on issues specific to engineering. Tonso (1996b) proposed that engineering education was "enculturation into a well-established system of practices, meanings and beliefs" as students "learn what it means to be an engineer" (p.218). Her recognition of engineering as a professional discipline, with a strong element of professional training and socialisation, supported my position that theorising based around the approaches taken in science provides an incomplete picture.

I commented earlier that engineers are not viewed as reflective of their profession, which could explain why the majority of critique and theorising has come from outside rather than from within the profession. In my study I have recognised the need for theorising to take account of the special nature of engineering education and find its own "voice".

Another limitation that I have identified was the tendency of previous research on female under-representation in engineering to cast women in a deficit role, aggregating them into one category, and viewing them as "other" or "exceptional" to the main stream of engineering. For me this created an inherent dilemma in that the usage of the term "women" provided a sense of difference and division. It implied that women form a unitary category, immediately constituted as "not men". This was at odds with more recent literature, discussed in Chapter 2, which acknowledges the diversity and complexity of many of the issues that go beyond biological sex. The term "gender" is now widely used to refer to the socially constructed features and attributes which are usually, but not necessarily, associated with one or other of the sexes (Gilbert, 1996). Typically, these qualities and attributes have become deeply entrenched in our understandings of gender, both masculinity and femininity, and act as deeply powerful agents shaping the perceptions of people and society. Awareness of gender stereotypes is intimately connected with changes in culture.

In my study I have consciously focussed on describing behaviours, values and even cultures as gendered, and not tied to one or other biological sex. In this way I provide the opportunity of a shift from a focus on difference, to a recognition of the potential for flexibility, commonality and inclusivity.

### 1.3.5 Previous studies hinting at “ecology” and “culture” need to be built on

#### *1.3.5.1 Early work*

Byrne (1993) explained the wide institutional and disciplinary differences in women’s participation in engineering education using the analogy of an ecosystem (the institution) in which organisms (new women students) adapt to their new cultures and are found in ecological niches (such as departments or schools). The notion of ecological niches linked the high level of women’s participation in some institutions or disciplines to the “fit” or “match” between the women’s personal values and beliefs and those of the institution or engineering sub-discipline. My research is premised on a shift from thinking of ecological niches, to the discourse of culture and subcultures.

Seymour and Hewitt’s (1997) comprehensive study of attrition in science and engineering courses was not written from the perspective of a cultural analysis. The students they interviewed, however, alluded to common practices and behaviours. Based on that data, they suggested to engineering faculty that “if the education they offer was to be as available to their daughters as to their sons” (p.314), a large part of the traditional pedagogical structure, along with the assumptions and practices which support it (in other words – the culture itself) would need dismantling.

As I have indicated previously, I have found few comprehensive studies of gender and the culture of engineering education, although Hacker (1981), Carter and Kirkup (1990), and McIlwee and Robinson (1992) provided departure points and influential insights into the cultural features of engineering education. In particular, McIlwee and Robinson’s (1992) well theorised study was focused on the profession and how gender and power relations intertwined in the engineering workplace, with only a passing reference to education.

#### *1.3.5.2 More recent work – Tonso and Lewis et al.*

The work of Tonso (1996a, 1996b, 1997) and Lewis et al (1998) has provided an important point of departure for my research.

Tonso's (1997) main thrust was how students acquire the existing culture and to what extent students whose niche in the culture is marginal or non-existent (e.g. women) could manoeuvre the culture. She wrote of the paucity of research studying the culture that exists, and proposed that this culture recognised certain forms of belonging, and cultural identities, in which men were recognised as engineers but women students were excluded (Tonso, 1997). One of her earlier papers (Tonso, 1996b) had highlighted some of the "cultural norms" of engineering education and their effect on women.

In a somewhat similar vein, the research reported by Copeland (1995), Lewis et al. (1998) and McLean, Lewis, Copeland, Lintern and O'Neill (1997) focussed on the educational and social aspects of engineering faculty culture, as evidenced at two Australian universities, and highlighted behaviours and practices that were consistent with an Anglo masculine culture. Their research was based on the premise that transformation of the engineering culture could only occur through an understanding of the characteristics of the culture and their links to a rigid and narrow version of masculinity. Their work emphasised that, although they viewed the culture as masculine, masculinity was not a singular phenomenon, varying with class, race, ethnicity, education and sexuality. Lewis et al (1998) named the dominant masculinity within the engineering culture as white, middle class and heterosexual. They argued that those who conformed to the beliefs and values of this group were the most powerful academically and socially, setting the norms for behaviour and practices and subordinating other masculine styles.

McLean et al. (1997) argued that, for a female student in this culture, only a limited range of behavioural responses were available, all of which were gendered identities having little to do with being an engineer. Lewis et al. (1998) again emphasised that the culture was not homogeneous and monolithic, describing behaviours linked to race, class, type of engineering, age and year level. This range was not explored in depth in their study, and their interviews focussed on Anglo students only, without differentiation by engineering sub-discipline. Their study revealed many of the cultural norms of engineering education prevalent at two Australian universities but, as the authors acknowledged, it left gaps in identifying systematic variations (subcultures) within the culture that require further investigation.

Lewis et al. (1998), like Seymour and Hewitt (1997) were reliant on interviews and focus groups for their data, and this provided much confirming evidence for their conclusions. However it has been suggested (Rosser, 1997; Tonso, 1997) that interview methodology may not provide a full picture of the cultural dynamics enacted in, and out of, classrooms. Several researchers supplemented interview data with techniques such as participant observation and videotaping (Cooney, 1991; Mares, Lewis, Lambert, Simpson, Copeland & Griffith, 1996; Rosser, 1997; Tonso, 1997). They noted that learning outcomes, in terms of both technical and group related skills, as well as assessment, were affected by gender dynamics and may have provided negative experiences for women.

None of the above cultural studies has explored in depth the links between gender and academic aspects of engineering education culture such as the role of mathematics and design, the influence of pedagogy and assessment and “ways of knowing”. There is a need for further studies investigating why cultural features are so enduring, how students learn them, and their interrelationship with gender. These are issues that I address in my study.

The growing recognition of the importance to women’s participation of the interaction of gender with culture has been reflected in the literature of recent years. It has been acknowledged that culture change will not necessarily occur as a result of increased participation, but as Cronin & Roger (1999) proposed, “solutions center on addressing both sides of conflict between feminine gender identity and the masculine culture”(p. 653). I am confident that better understandings of the social construction and dynamic nature of both “gender” and “culture” will assist in removing the limitation placed on female participation.

In summary, my analysis of the limitations of current practice and theorising led me to conclude that cultural change must be based on an awareness of the basic beliefs, values and assumptions held by both staff and students, and an understanding of how they combine with the construction of the discipline to implicitly guide actions.

## 1.4 Research Questions

Building on the rationale presented in the previous section, and recognising the perspective I bring to this study, the overall aim of my study is to identify the values, beliefs and assumptions of the culture of engineering education that underpin practices and behaviours in one institution. In so doing, I will provide a model upon which cultural change, particularly that which could be advantageous to the participation of women, could be effected by engineering educators.

To achieve that aim, I have identified the following three research questions:

- What are the dimensions/elements of the culture of engineering education in the case study institution and how do they interact with gender?

- How is the culture of engineering education learned in the case study institution and how does gender interact with this learning process?

- Viewing sub-disciplines as subcultures within the culture of engineering education in the case study institution, how do these subcultures interact with gender?

## 1.5 Theoretical framework

I deemed it necessary in this study to choose a theoretical framework which was not only appropriate for the study of engineering education but which was also accessible to engineering educators. Amidst the wealth of definitions available in the literature relating to culture, Schein's influential model (1985, 1991, 1992) provided one of the few conceptual frameworks for studying culture within organisations. I have used Schein's model as a starting point because of its clear delineation between the three levels of culture shown in Figure 1.1; the observable manifestations of culture (Artefacts), the values and behavioural norms that underlie the Artefacts and, at the deepest level, a core of beliefs and assumptions.

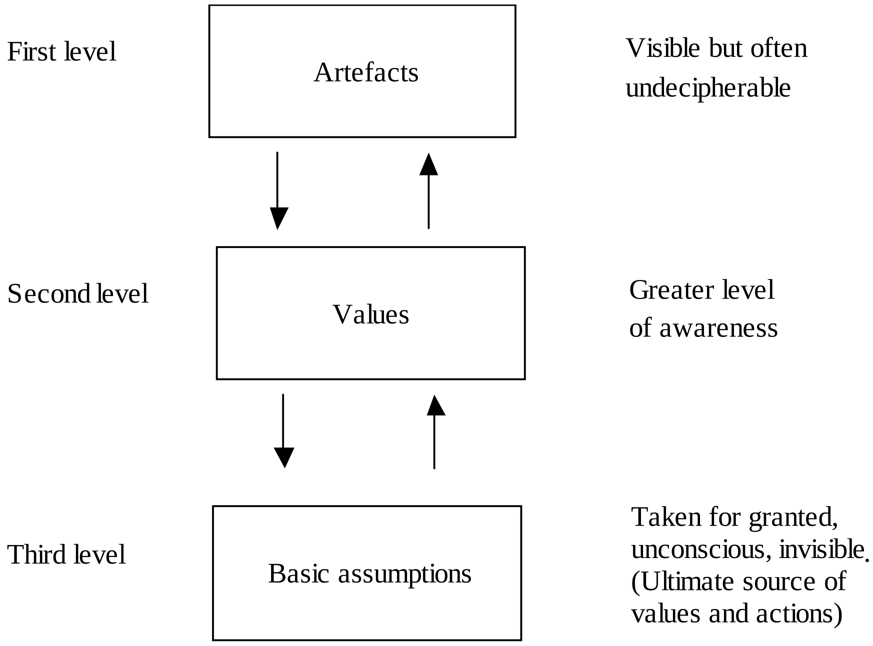


Figure 1.1 Representation of Schein's three levels of culture (adapted from Schein, 1985, 1991, 1992)

According to Schein, the essence of culture lies in this core of basic beliefs and assumptions, which reached outward to become values, and behavioural norms, which in turn guided choices and actions. Schein defined culture as:

> *…a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems* *Schein, 1992, p.1*

Schein postulated that, if any group was to be considered to have a culture, then three features were necessary: firstly, a history of shared experience; secondly, some stability of membership in the group; and, thirdly, a process of learning, at a conceptual level, for any newcomer joining the group. If these three features were present, then shared knowledge, meanings or assumptions would become possible. Schein was very clear that unless these three features were present, a group would not have a culture but would just be a group of people acting in loosely connected ways. Both engineering education as an academic discipline and my case study institution with approximately 70 years of history, can be seen as having these pre-requisites of shared experience, stability and learning for cultural formation.

Later authors have challenged Schein's model in a number of ways that are relevant to its use for my study. I will expand on these in Chapter 2. In particular, subculture researchers (van Maanen & Barley, 1985) disputed the Schein assumption of an organisational culture as unitary or integrated. They envisaged a differentiated model with numerous small cultures, each a consistent, consensual, stable whole, existing within the same organisation. Schein, however, did not see his model as inconsistent with the existence of subcultures operating as stable wholes with shared experience, namely "cultures within cultures" (Schein, 1985, p.7).

As I explain further in Chapters 2 and 3, I have used Schein's framework, combined with an interpretivist perspective. In considering the impact of the culture of engineering education on the participation of women, I saw it as necessary to not only define the dimensions or features of this culture and any subcultures, but also to interpret and make visible the ways gender interacts with this culture as the process of engineering education acts "as enculturation into a well-established system of practices, meanings and beliefs" (Tonso, 1996b, p.218).

### 1.5.1 Methodology

In choosing a research design, my first priority was to choose methods of data collection and analysis which would bring to the surface the shared meanings, tacit knowledge and lived experience of the members of the culture. These I saw as essential to exploring the basic beliefs and assumptions at the core of Schein's theoretical framework. My second priority was to allow theory to emerge inductively from the data, in conjunction with my acknowledged background and experience in the field. And thirdly, it was especially important to me, if I was to work in a qualitative paradigm rather than my more familiar quantitative paradigm, that the data collection and analysis processes were transparent and provided a clear chain of evidence to support my findings and subsequent theory development.

With these criteria in mind, my study is an interpretive (theory building) case study including, although not exclusively, ethnographic methods within an overarching interpretivist research paradigm. I discuss and justify this choice in Chapter 3.

As described in detail in Chapter 3, my research design and methodology have been selected to satisfy the four main criteria of validity and trustworthiness for qualitative research (a) credibility (b) dependability (c) transferability and (d) confirmability (Lincoln & Guba, 1985).

## 1.6 Analysis and findings

As my data collection and analysis progressed, so did my evolving understanding of: firstly, the sense of depth and interconnected layers within the outermost, observable level of culture and secondly, the dynamic relationships between the levels of culture. Consequently I progressively amended Schein's diagrammatic model of culture analysis to more clearly illustrate those understandings. This amended model, presented in Figure 3.1, framed my study.

Using this model to answer my first research question I have teased out Schein's first level, Artefacts, into three categories for the observable and tangible manifestations of culture. The complexity and interdependence of these manifestations became quickly apparent. I have grouped them as: firstly, what you can see, touch or read as an outsider or visitor – buildings and facilities, publications, mission statements, statistics, and dress – these I have named Artefacts; secondly, the practices of teaching, learning, assessment, and regular events which become apparent with further exposure – the ways we do things round here – these I have named Practices; and thirdly, the way members of the culture respond to artefacts and practices – their behaviours, language, humour, and relationships – these I have named Behaviours. My grouping of my findings in this way was in accordance with my perceptions of the levels of understanding depicted in my model. The detail of the data I have provided has clearly evidenced a variety of manifestations at the level of Artefacts, Behaviours and Practices, which reinforced enculturation into shared values and norms, the second level of the culture.

At the third level of my cultural analysis, I grouped the shared basic beliefs and assumptions, that I had interpreted from my data as forming the essence of the engineering culture, in seven dimensions. This followed the style of Schein's framework. In each of these dimensions I identified ways of doing, thinking, behaving and relating which characterised engineering and engineers within higher education.

Some features of the culture at the case study institution may have been unique, such as the tradition and valuing of integration between the sub-disciplines, and their sense of identity and isolation from the wider university. However, many of the beliefs and assumptions that I have identified in the academic culture appeared to be the source of practices and behaviours identified in the research literature as common internationally.

The seven dimensions that I have identified can be summarised as:

- Engineering way of thinking
  What kinds of knowledge were valued? What was perceived as truth? Was there a prevalent "way of thinking?"
- Relationship to the environment
  How does engineering education fit within its environment?
- Engineering identity
  What attributes and qualities were inherent in being "an engineer"? Who fitted in and was successful?
- Engineering way of doing
  What was perceived as the "right" way to teach and learn?
- Time
  How was time used and how was it defined?
- Relationships
  What was the 'right' or accepted way for people to relate to one another?
- Homogeneity
  Is homogeneity desirable or necessary? How is difference accepted?

The detail of the shared beliefs and assumptions I provide in Chapter 7, emphasising four themes which wove through them: first, the "hardness" of Engineering (with a wealth of understandings around "hard"); second, the existence of a strong communal sense of identity as engineers; third, a perceived need for "mates" and "belonging" for academic survival; and fourth, a readily recognised "way of thinking" that valued pragmatic, quantifiable, open-ended problem solving with real life constraints and top-down methodologies.

Espoused values were not always matched by cultural norms. As a consequence I identified tensions and contradictions such as:

- Conflicting imperatives in endeavouring to serve the needs of academia and the profession;
- The staff desire for deep learning vs. student instrumentalist attitudes in which surface learning prevailed;
- The valuing of group and team work vs. the academic traditions of individualised, ranked assessment;
- A common perception of a mismatch between the rhetoric of valuing teaching excellence and reward systems such as promotion.

I then examine the dimensions of this overarching engineering education culture and demonstrate that the ways of knowing, doing, being, and forming relationships, which I had identified, were founded on and sustained by shared values, beliefs and assumptions. I discuss the links between the latter and masculinity: in particular, a form of masculinity in the local culture which resonated hegemonically with that of the white (or NZ European) male.

My findings relating to the second research question ("How the culture was learned") are woven throughout Chapters 4, 5 and 6. I provide examples from the teaching and assessment practices of the first year classes, and events such as Orientation, that illustrate the ways in which students learned how to operate successfully within the learning environment. Within that first year they gained a significant understanding of the "engineering way of thinking and doing". For final year students, a notable feature from my data, both questionnaires and interviews, was the high level of commonality cutting across both gender and ethnic differences, demonstrating the strength of enculturation processes. The interaction with gender wove throughout this enculturation. First year students viewed a wide variety of gendered behaviours as acceptable. For senior students, however, acceptance was implicitly gendered and spoken of as being “one of the guys”.

My third research question is discussed in Chapter 8, in which I examine the engineering sub-disciplines as subcultures within the overarching engineering culture. My analysis suggests that the differential participation by women in the sub-disciplines is a response to complex and sometimes apparently contradictory driving forces. The attraction of status and employment potential of some sub-disciplines appears to be in opposition to other sub-disciplines that have ways of knowing with which women might be most comfortable. Amidst the overall masculinity at academic and behavioural levels that I identified for engineering as a whole, I found evidence that masculinity was constructed and manifested in the sub-disciplines in ways that had implications for the participation of women. I identified a range of masculinities from the traditional New Zealand male model of masculinity found in Civil and Mechanical Engineering, to the technological obsession of Electrical Engineering, and the “softer”, less-specific masculinities of both Chemical Engineering and Engineering Science. In the instance of Engineering Science, the culture appeared to have “opened up” to value and include women, whereas in the other disciplines, even Chemical and Materials Engineering, the level of integration for female students, as women and as engineers, appeared to be linked to the extent they needed, and were prepared, to identify with masculine qualities appropriate to the discipline. Even within the two most “masculine” disciplines, albeit with masculinity constructed in contrasting ways, the finding of a supportive niche appeared to result in the fulfilment of academic and personal potential for women.

In Chapter 9 I summarise my analysis and definition of the gendered culture and subcultures of engineering education, reported on in detail in Chapters 7 and 8. I then examine the conflict and inherent duality, evidenced in this study, of constructing gendered identities. I name these “Doing Man” and “Doing Woman” within the masculine norms of “Doing Engineer”. I follow by considering the implications of my findings for increasing the participation of women in engineering education.

For a woman to be taken seriously as an engineer, I conclude that she adopts, sometimes consciously but usually unconconsciously, behaviours and responses which in the local culture have been stereotypically associated with masculinity whilst maintaining those aspects of femininity she deems valuable. She constructs her own form of dual identity, which enables her to feel valued as a woman and as an engineer. A strong theme running through my data was that it was "OK" to be a woman in engineering but a woman engineer was likely to be different from other women, with both positive and negative consequences, depending on perspective and context. For men, I found no sense of the dual identity or conflict evidenced for women, who had limited positions to occupy.

## 1.7 Significance

Change does not occur as a result of a single study but as a gradual accumulation of knowledge and experience. In this sense, my study adds a new voice to the literature, and it has significance both theoretically and practically for the discourse surrounding women's participation in engineering education.

The theoretical significance of my study is that, using a cultural analysis, it has addressed the causes and sources of practices and behaviours, not just their visible effects. I have proposed an accessible model for this type of analysis, firmly grounded on Schein's respected theoretical framework. My model moves beyond observable manifestations to the level of values and norms, and even further to the level of unconsciously shared beliefs and assumptions, which I have argued are the core or essence of culture. The extension of this model, and my consequent findings around subcultures and their implications for the participation of women, fills a gap in current theorising and research.

I have built on gender research about the dynamic construction of gendered identities, and the concept of "dual identities". Using these theoretical bases I have encouraged the view that "doing woman" and "doing engineer" might not be mutually exclusive, despite the identification of engineering education as a masculine culture. My analysis of ways of knowing, doing and behaving, within engineering, has supported approaching gender as an on-going, dynamic construct, which provides a useful, explanatory perspective with which to deconstruct the persistent under-representation of women in engineering.

The practical significance of my study takes account of the established practice within academia of basing strategic planning on a foundation of theory and research. I have provided a model of the engineering education culture that is accessible in theory and discourse to both engineering educators and advocates for women in engineering, and which will be of practical significance at strategic and operational levels in the implementation of desired values and goals. My research provides a basis for assisting researchers, practitioners and policy makers to conceptualise and redefine issues, and enhance their understanding of the conditions that are required to increase the participation levels of women in tertiary engineering courses.

## 1.8 Overview of thesis

In this introductory chapter I have provided background information and a rationale for my choice of topic and research questions. I have included a consideration of my perspective and position, together with a brief summary of my analysis and findings.

A comprehensive literature review in Chapter 2 covers the relevant literature on culture, gender and engineering education, in which I establish in detail gaps in the research which this study seeks to rectify. In Chapter 3, Methodology and Analysis, I describe the research design and proposed model for my cultural analysis and include detail of the methods and procedures that I used in my data collection and analysis.

Chapters 4, 5 and 6 then contain my findings at the first level of my analysis, grouped as the domains Artefacts, Practices and Behaviours, within which I describe the observable, tangible manifestations of the culture as well as the lived experiences of students and staff. I include in each chapter the second level of analysis, my interpretation of the shared values and cultural norms. In Chapter 7, I bring together my findings from Chapters 4, 5 and 6 to present my third level of analysis, the dimensions of the culture and their interaction with gender, and in so doing answer my Research Questions 1 and 2.

My third Research Question is answered in Chapter 8, in which I focus on the interaction of gender with sub-disciplinary subcultures and the implications for women's participation.

Finally in Chapter 9, I draw the thesis together with a special focus on the formation and maintenance of gendered identities within the culture of engineering education and implications for the participation of women. In considering the theoretical and practical significance of my findings I present a model for cultural change. I close by providing recommendations for future research and strategies, which have the potential to enhance women's participation and success within engineering education.

# Chapter 2

## Literature Review

*We need to gain a clearer picture of the existing cultural dynamics within university engineering faculties in order to understand the ways in which these cultural factors perpetuate the under representation of women* *McLean et al., 1997, p. 143*

## 2.1 Purpose and outline of the chapter

My primary aim in this chapter is to critically review the literature pertaining to the culture of engineering education and its interaction with gender, as the departure point for my study. My fundamental premise, well supported by the wide range of literature cited in Chapter 1, is that the culture of engineering education interacts with gender in ways which inhibit growth in female participation. In Chapter 1 I briefly described limitations in current initiatives and theorising, the research base of which I will explore in further depth in this chapter, identifying gaps and unanswered questions.

My research questions encompass the fields of culture, engineering education and gender, requiring my study to be informed by, and grounded in, a very wide ranging research literature, studied within a variety of theoretical, epistemological and methodological research paradigms. In this chapter I refer to a subset of that literature, chosen for its contribution and relevance to the aims and methodology of my research.

In the first section of the chapter I discuss and justify the assumption that engineering education has a recognisable culture, and I review literature contributing to an understanding of the cultural features of engineering education as a professional academic discipline. Having identified a lack of reflection on this topic from within mainstream engineering I follow on with a review of the literature on which I based my working definitions of the terms “culture”, “gender” and “gendered culture”. In the final section I return to the focus of my study, reviewing the research literature, predominantly emanating from the feminist critique, of the intersection of gender with the culture of engineering education. My summary links the gaps found in this literature review with my research questions and the goals of my study.

## 2.2 Engineering Education

In this section I review the literature relating to engineering education and its culture. Initially I consider perceptions about the professional and academic cultures, within whose influence engineering education as a professional academic discipline is positioned. I follow with a review of the literature and research applying cultural studies to academic disciplines, and an overview of the identified features of engineering education that might contribute to an understanding of its disciplinary culture.

### 2.2.1 Professional vs academic

In professional academic disciplines an almost inevitable tension has been seen to exist between the needs and values of the profession and those of academia (Alvesson, 1993; Becher, 1981; Johnston, Lee & McGregor, 1995b; Lee & Taylor, 1996b). Engineering education takes place in the context of training students to practise as professional engineers, whose work involves living with compromise, and optimising within constraints, with rarely one “right” answer. In contrast, as an academic discipline, engineering education has been identified as using an engineering science approach, which is positivist, and looks for theoretical answers from “bounded questions” (Becher, 1981; Johnston et al., 1995b).

Goodlad (1984) viewed professional accreditation, representing the control of expert knowledge by the moderation of the content and delivery of professional engineering courses, as lying at the heart of the concept of a profession. Within the university system, with its focus on high academic and research qualifications, the professional disciplines are seen to highly value professional qualifications and experience (Becher, 1981).

### 2.2.2 A Professional Engineering culture?

A lack of reflective thinking within the profession was identified by Solomon (1996) who suggested that only a handful of engineers had set about the contemplation of the nature of the discipline and its products. Statements such as “[E]ngineers are optimistic can-do people. They want to build stuff" (Hazeldine, 1997) reinforced the notion that "the underlying nature of engineering is for the most part perceived to be action, and this has limited the opportunity for and perhaps the validity of reflection" (Solomon, 1996, p.146).

Consistent with this identification of a lack of reflective thinking, I found no studies of the culture of engineering from within the profession. However, a recognisable professional identity, which I discuss briefly in this section, appears to be an implicit assumption in the work of Florman (1968, 1984), Goldman (1990), Koen (1984), Prussia and Birmingham (2000) and Solomon (1996, 1997).

Samuel Florman (a civil engineer who wrote extensively about the engineering profession including its joys and passions) commented in his book *Engineering and the Liberal Arts* (Florman, 1968) that, historically, the image of engineers has been of a group with no verbal skills, inarticulate, prejudiced, conservative, and non-involved. In a later paper, he commented (Florman, 1984, p.52) that "there is a need for engineers – men as well as women – to be liberally educated, so that their own lives can be enriched, their profession ennobled, and society improved".

In contrast to the context free conceptions of rationality traditionally promoted as embedded in mathematics and physics, Goldman (1990) argued that "[O]n no account could the object of engineering knowledge or the specification of engineering problems be claimed even by engineers to be impersonal, value free or a matter of fact" (p.131) as engineering outcomes were "explicitly inseparable from the intentional, contingent, and value laden contexts of their formulation" (p.129). This subjectivity, Goldman suggested, was derived from the design dimension of engineering, problem solving, which he saw as central to engineering.

The design dimension and the use of engineering method appeared to be so tacitly understood within engineering that they were rarely mentioned in discussions of the profession and its culture. However, I did find some explicit descriptions of the engineering method. Koen (1984) (for example) wrote that "the essence of engineering is not captured in the commands: analyze, synthesize, evaluate" but "engineering method is the use of heuristics to cause the best change in a poorly understood situation within the available resources" (p.151). The sense of engineers designing and developing products within constraints was also implicit in Prussia and Birmingham's (2000) differentiation of engineering from science by using " 3 D's":

| | |
|---|---|
| *D – Determine* | - *needs and constraints are determined and problems are defined* |
| *D – Develop* | - *designs and processes are developed and evaluated for feasibility and alternatives are selected* |
| *D – Deploy* | - *specifications and plans are deployed, the project is completed and performance is evaluated* |

Prussia & Birmingham, 2000, p.436.

Solomon (1997) suggested that a philosophy of engineering was overdue and she presented a philosophical framework, referring back to Greek philosophers, that created a sense of inter-relationships. Her argument complemented that of Goldman. In contrast to Plato's search for eternal and unmoving Truth, which Solomon saw embodied in scientific endeavours, she suggested that the Sophists' ideas of the Good had much to offer engineering. "After all", she wrote, "engineers don't look for the right answer they look for the best one possible in the circumstances. They don't try to create what is right, they try to create what is good" (p.126). She was also firmly convinced that Engineering, so commonly perceived as applied science, was an independent entity with a philosophy of its own.

The "service" role of professional engineering was emphasised in the 1996 *Review of Engineering Education in Australia* (IEAust, 1996), which provided a thorough and widely representative effort to consider the nature of the profession and the education necessary to sustain it. Distinctive features of traditional professional engineers, that the Review identified as enduring, included their:

> *…ability to formulate problems and synthesise solutions, integrating technical understanding from various sources into systems to serve society's needs, and thus creating wealth for society in a competitive world* *IEAust, 1996, p.19.*

The authors I have quoted here did not write explicitly about culture, but I will draw on their contributions to inform my research findings about the profession for which today's students are being educated.

### 2.2.3 University culture

Before specifically addressing the literature on Engineering Education as an academic discipline I see it as appropriate to recognise that many of its values and behavioural norms would reflect those of the higher education or university culture within which it resides. Tierney (1988) acknowledged the complexity within the seemingly unified higher education institutional culture and commented that:

> *…analysis of the organisational culture of a college or university must occur as if the institution were an interconnected web that cannot be understood unless one looks not only at the structure and natural laws of that web, but also at the actors' interpretations of the web itself* *Tierney, 1988, p.4*

Trowler (1998) also viewed the culture of higher education institutions as "numerous cultures in operation simultaneously" rather than unitary. Becher (1988) had previously proposed that the higher education culture operated in three arenas: front-of-stage (the public arena); back-stage (where deals are done); and under-the-stage (where gossip is purveyed) and Trowler commented that any model of culture must consider each of these three arenas or miss much that was important in understanding the cultural life of an institution.

Higher education has been seen to have a long history embedded in traditional approaches (Armstrong, Thompson, & Brown, 1997) and this has resulted in internationally similar curriculum content, processes and practices (Jones, 1990). Taken-for-granted sets of behaviours, which Jones viewed as cultural norms in higher education, include: knowledge transmission, almost exclusively in some courses, via lectures; individualised, competitive, assessment methods using sets of artificial problems and questions to be answered in strict time limits; and success defined as the aggregated marks reaching some arbitrarily chosen figure – usually 50%. Although autonomy and independence have been seen as highly valued by academic staff (Lewis, 1996) this does not appear to have been reflected in the prevalence of traditional "transmission" teaching and assessment methods. It has been suggested that one cause of this conservatism may be a higher education system where success, i.e. promotion, for academic staff is dependent on the "continued demonstration of frontier level technical research" (Becher, 1989, p.3), which does not necessarily imply competency or innovation in teaching.

Whereas a university education was formerly viewed as a time for experimentation and learning, intellectual growth and debate, the current norms have been identified as: students buried under financial constraints; a workload which equates quantity (time spent in lectures and numbers of assignments) with worth, rather than quality (Jones, 1990); and, education seen as access to a job (Armstrong et al., 1997).

### 2.2.4 Disciplinary cultures

Within the overarching university culture, faculties and academic disciplines have recognisably different epistemologies, pedagogies and research paradigms (Neumann, 2001), which have been viewed through a cultural lens (Becher, 1981; Gaff & Wilson, 1971).

Gaff and Wilson (1971) provided two explanations for the existence of faculty (disciplinary) cultures; firstly, by using a "theory of socialisation which asserts that people acquire the characteristics of an intellectual culture by being socialised within it" and secondly, by using a "theory of attraction which holds that people are attracted to an intellectual culture which is consonant with their predispositions" (p.197).

A sense of puzzlement at the difficulties with teaching and research across disciplinary boundaries, coupled with a long-standing interest in different epistemologies led to Becher's studies in the 1980s (Becher, 1981). He observed that "at distinguished institutions teachers are oriented to their disciplines not their institutions" (1989, p.17). For clarity, he defined an academic discipline as a group for which a "free standing international community has emerged with its own professional association and international journals …every department does not represent a discipline" (1989, p.19). Comparing disciplines in different countries, despite some variation in approach, he found strong resemblances as if 'between different branches of the same family"(1989, p.22). Becher viewed academic disciplines as "cultural phenomena, embodied in collections of like minded people, each with their own codes of conduct, sets of values and distinctive intellectual tasks" (1981, p.109) and later named them "academic tribes" (Becher, 1989).

Despite these strong arguments for disciplinary cultures few studies exist for the physical sciences or engineering and those that do display varying levels of understanding and perspectives relating to culture. Traweek (1984) investigated the world of high-energy physicists and sought to understand their values and “common sense” view of the world. Bernstein, discussing the computing culture, defined culture as “patterns, traits, products and artefacts of a particular class or population” (Bernstein, 1997), and provided, as examples of the culture, the non-academic literature founded in popular magazines, best-selling books, movies and jokes. Other authors (Nespor, 1994; Thomas, 1990) who focused on the way students construct their identity in the subject area of Physics did not write specifically about the disciplinary culture of Physics, but both Thomas and Nespor clearly described the norms and common understandings that students had about the discipline and their learning environment.

My search of the literature has not revealed cultural studies that focused on engineering education as an academic disciplinary culture from within mainstream engineering, excepting those arising from the feminist critique, which I will discuss in a later section. A considerable body of literature and research does exist, however, that illuminates the behaviours, practices, and attitudes that can be viewed as forming cultural norms within engineering education. I review this literature in the next section, together with the calls for change that arose in the 1990s.

### 2.2.5 Engineering – an academic discipline

In critiquing the way engineering has evolved as an academic discipline, Lee and Taylor (1996b) argued that there were few mechanisms for reflective critique within the discourse of academic engineering that made it possible to consider knowledge and ways of knowing which went beyond or called into question the discipline’s present definitions of itself. They viewed this, in part, as a consequence of the intellectual isolation of engineering faculties within universities, created and maintained by both sides of the technology/humanities divide.

Engineering, as an academic discipline, has been identified by Johnston, Lee and McGregor (1995a) as founded upon and validated by engineering science. In an examination of the discourses of engineering (the ways in which engineers define their practice), Johnston et al. concluded that engineering education was 'captive' to the domination of the discourse of science to the exclusion of other competing discourses such as management, politics and sociology among many. They argued that, in engineering during this century, engineering science has made up the vast bulk of engineering education, to the almost total exclusion of questions of professional identity or the social, institutional and political effects of engineering practice.

The course content of most engineering degrees in Australia has been said to be obsessed with the technical, the mathematical and scientific, with an almost complete neglect of social, political and environmental issues (Beder, 1998). In the late 1990s, however, I inferred from presentations at conferences such as those organised by the Australasian Association for Engineering Education, that curriculum changes at a number of Australian and New Zealand universities appeared to have been directed toward preparing graduate engineers with an increased awareness of the broader issues of the engineer's relationship to society. Typically, the majority of engineering curricula in the 1990s contain management, ethics and professional development modules, although it has been suggested (Stonyer, 1998) that these topics are often positioned as "add-on", non-technical courses and therefore located marginal to the dominant technical curricula.

#### *2.2.5.1 Curriculum and content*

In common with other professional, academic programs, engineering education is required to provide essential core knowledge to ensure national and international professional accreditation. This standardisation of required course elements makes it possible to compare graduates of both geographically and ideologically separate institutions.

Features that have been identified in critiques as common throughout engineering curricula are:

- Teaching is perceived to be based on the transmission of a fixed body of apparently immutable knowledge (Ford & Ford, 1994) with all subjects viewed as essential for success as an engineer (Lewis et al., 1998);
- An overwhelming concern with numbers and mathematical analysis (Beder, 1998);
- Closed or 'bounded' problems are simplified to remove the complexities of 'real life' engineering problems (Johnston et al., 1995b; Roberts & Lewis, 1996);
- The packaging of fundamental engineering science content into discrete subjects (Ditcher, 1998) causing knowledge to be fragmented and students left to make the connections between the technical areas (Roberts & Lewis, 1996);
- Rigid course structures allowing little choice or opportunity for study of subjects from other disciplines, which stifles opportunities for students to develop intellectually to the extent they desire (Ditcher, 1998; Taylor & Johnston, 1991);
- Assessments typically in terms of numeric outcomes, with normally, a "right" or "wrong" answer (Seidel, 1996);
- Teacher-centred pedagogy (Ditcher, 2001), transmitting knowledge which students receive and, under examination give back, in a receptive and obedient relationship (Lee & Taylor, 1996a).

Formal curricula provide evidence of what is taught and how it will be taught. Over thirty years ago, however, Snyder (1971) in his study of a large American engineering school found evidence of a hidden agenda, a hidden curriculum, which determined the way in which participants (students) read the cues and adapted to their immediate educational circumstances. In particular Snyder was led by his own experience to the realisation of "the importance of the context, the emotional and social surround of the formal curriculum" (1971, p.4). For Snyder the hidden curriculum determined not only what was learned, but also, how it was learned. This often implied, he suggested, a contradiction between formal requirements and the nonacademic rules (and explicit sanctions for breaking them).

Lee and Taylor (1995a) also recognised the power of educational curricula and practices to shape and control, and described engineering education as the production of “disciplined subjects”. In a later collection of work dealing with aspects of the “hidden curriculum” in education, including engineering education, Margolis (2001) cited education as “systems of domination that persist and reproduce themselves without being consciously recognised … as students encounter norms, values and beliefs through the rules and practices of daily routines” (p.12).

#### *2.2.5.2 Workload*

Studies of engineering education invariably commented on the huge workload experienced by students. Seymour and Hewitt, (1997) from the USA, used the term “hard” or “hardness” in speaking of the large volume of work required in engineering courses, coupled with the high speed at which it must be completed. Their comprehensive study across several institutions identified that students commonly spoke of “survival” and the need for small support groups and collaborative learning. In a New Zealand study, Ditcher (1998) concluded that one consequence of the high workload was that students adopted an instrumental perspective on their work, accepting the pre-existing body of knowledge on trust, with no time to think or question what they were learning. In the 1996 *Review of Engineering Education* (IEAust, 1996) it was noted that many academics agreed with students that courses were overloaded and that; “the overloading must be seen as a factor contributing to the attrition and low progression rates for the less well prepared students and demotivation for many of the others” (p.57). The use of “ordeals” in engineering education was discussed by O’Neal (1994) as a remnant of (American) engineering’s early roots in military training. This echoed observations made by Hacker (1989).

#### *2.2.5.3 Personal attributes*

Various studies have given information on the type of person traditionally recruited to engineering. Beder (1998) named the most obvious and uniform characteristic as sex. Most engineers have been male, which inevitably narrowed the diversity of engineering students.

Diversity, in the form of rapidly increasing numbers of international and new immigrant students, in both Australia and New Zealand, coupled with the increasing participation of women in engineering, made me wary of using generalisations about the attributes of engineering students. In the past however, a variety of assertions have been made such as:

- Even as students, engineers disliked ambiguity, uncertainty and controversy and preferred things to be ordered and precise (Beder, 1998, p.13);
- The vast majority of engineering students are introverts who shun people-oriented situations. They are inept at verbal communication, assertiveness, leadership and conflict management (Harrisberger, 1984 p.137);
- The engineering student is a pragmatist with little tolerance for non-quantifiable topics (IEAust, 1996, p. 50);
- Engineering students have a perceived reputation not only as “macho, beer drinking louts” but also as “dorks and geeks” (Lewis et al., 1998, p. 70).

Mathematics and science ability has been an important selection criterion for study in engineering, and whilst this does not preclude written and verbal skills, it appeared to be a common perception that engineers were more comfortable with quantifiable problems with clear-cut solutions. Beder (1998) cited a variety of international studies which emphasised that engineering students were especially concerned with order, had a low tolerance for ambiguity, and avoided material that was imprecise, human and controversial. Even the styles of written communication employed by engineers reinforced this perception. Seidel (1996) reported that engineering students were usually good (or learned to be good) at report writing and technical documentation that used concise forms, diagrams and mathematics, whereas they were not good at critical analysis using free form commentary, either verbal or written where none of their preferred concise communication tools were appropriate.

Engineering students have been said to proudly differentiate themselves from other students (Ditcher, 1998) deriving status from their high number of contact hours and heavy workloads, in contrast to arts students who they perceived as “not doing terribly much work” (Lewis et al., 1998). They viewed other disciplines as “soft” options (Ford & Ford, 1994). “Soft” in this usage means “easy, requiring little effort” but Ford and Ford viewed this term as also suggestive of "caring and comforting", qualities often associated with the feminine. This disdain towards other disciplines was also linked by Ditcher (1998) and Seymour and Hewitt (1997) to the view that an engineering degree was seen as more likely to lead to a well-paid job than either an arts or science degree.

The stereotypical link between being an engineering undergraduate and excessive alcohol consumption has been seen as prevalent in both Australia and New Zealand (Bassett, 1969; Hansen & Godfrey, 1997; Jolly, 1996; McLean et al., 1997). Hansen and Godfrey (1997) regarded the origins of this reputation as lying in the traditional, predominantly male, Anglo student population of engineering schools whose ethic was "work hard, play hard". This stereotype has been perceived as being challenged by the increasing cultural diversity of engineering schools (Hansen & Godfrey, 1997; King, McGregor & Marks, 1996) and the intensified economic and time constraints placed on students by much increased tuition fees.

The literature referred to in this section has clearly identified that engineering education has been seen to have a strong core of common norms of practice, knowledge, understandings and behaviours across national and institutional boundaries. This core of common cultural norms confirmed my assumption that engineering education has a distinct disciplinary culture.

### 2.2.6 The culture of engineering education

The assumption that engineering education had a distinct culture appeared to be implicit in the 1996 Review of Engineering Education *Changing the culture: Engineering education into the future* (IEAust, 1996). Previous reports and reviews on engineering education in Australia had focused on appropriate structural or curricular responses by engineering schools to changes in the economy and higher education system. The title of the 1996 Review and its opening words clearly stated that more than a structural change was required:

> *The Review of Engineering Education is recommending no less than a culture change in engineering education* — *IEAust, 1996, p.6*

and directly linked the culture of engineering education to the profession:

> *…there can be no doubt that the culture and core values within engineering schools shape our graduates and in turn the profession* IEAust, 1996, p. 51

Prior to this Review the first mentions of "culture" appeared to have arisen from discussions at the First Australasian Women in Engineering Forum in 1994, aptly titled *Transforming Cultures: Nurturing Diversity in Organisations*. In particular, this forum highlighted the relevance of culture to the participation of women and other minority groups in engineering. Shortly thereafter, Taylor and Yates (1995) named Electrical Engineering as a "culture" with its associated "taken-for-granted codes of action", and used "sink or swim" and "filter of students rather than a pump" as cultural metaphors to describe a model or process of education that resulted in high attrition rates.

As part of the widespread consultation that resulted in the 1996 Review, advocates for women in engineering submitted *The National Position Paper for Women in Engineering* (Roberts & Lewis, 1996). One of the most critical statements of this position paper, demonstrating an understanding of the concept of culture, was:

> *It is our belief that the transformation of the engineering profession and culture requires conscious recognition of the values that underpin the existing culture and identification of the values towards which we wish to move.*
>
> *Roberts & Lewis, 1996, p.7*

The position paper stressed the importance of personal and institutional values in the formation of behaviours, reward systems and structures.

The 1996 Review appeared to have built on the discourse of culture transformation. However, as identified by Ayre and Mills (1997), the Review made only passing reference to the beliefs, values and attitudes in the engineering community from which the culture derived. The Review did highlight the need to recognise "the differences between the values that underpin the existing culture and the espoused values to which it aspires" and referred to "shifts in thinking" (p.21), but a clear definition of those current underlying values was not provided. The assumption of a unified or homogeneous culture of engineering education regardless of institutional and discipline specific differences was implicit throughout.

This call for change in the culture of engineering education appeared to rely on the premise that engineering educators understood the concept of ‘culture’ and its relationship to observable behaviours and practices. The literature of the time, and the plethora of papers at the Australasian Association of Engineering Education conferences since 1996, have confirmed for me that a very high proportion of engineering educators do not share the familiarity and understanding of social scientists around the concept of culture. The focus appears to have continued to be on the characteristics of the behaviours and practices, “what is and what they should be” rather than the values, beliefs and assumptions which underpin “how they came to be”.

The lack of understanding displayed by mainstream engineering educators of multidisciplinary concepts such as “culture” was embodied in Taylor’s (1998) contention that there was a growing need for engineering to develop space and a voice to know itself, its culture, its discourses and possibilities. Engineers worked more commonly with certainty and facts, but Taylor recognised that engineering may need to use the language of other disciplines “in light brushstrokes” and multidisciplinary settings. If engineering was to participate in the debates and discussions that form the values, norms and directions of our world, she saw a need for that space and “voice” to come from within engineering rather than from the margins or “other”.

I saw it as reasonable, logical and urgent, therefore, to assume that if change was to be effected, the dimensions of the culture of engineering education, and the processes by which that culture was learned and sustained, needed theorising in a way that was accessible and acceptable to engineering educators.

In the next section, I provide a review of cultural theory that resulted in my choice of the theoretical framework which provided a basis for my study of a disciplinary culture.

## 2.3 Culture

> *Man (woman?) is an animal suspended in webs of significance he himself has spun. I take culture to be those webs, and the analysis of it to be therefore not an experimental science in search of law but an interpretive one in search of meaning*
>
> *Geertz, 1973, p. 5*

### 2.3.1 Defining 'culture'

The concept of culture has been central to anthropology and folklore studies for over a century. Sociologists, with their concern for contemporary societies, developed more fully the notion of group cultures and this opened the door to the study of organisations and institutions. A growing body of literature in organisational studies began to appear in the 1970s and flourished in the 1980s with definitions of culture appearing as shared knowledge (Spradley, 1979), understandings (van Maanen & Barley, 1985), values (Hofstede, Neuijen, Ohayv, & Sanders, 1990) and assumptions (Schein, 1985).

From its earliest studies organisational culture was influenced concurrently by two distinct approaches. Smircich's often cited overview of the concepts of culture in organisational analysis (Smircich, 1983a) distinguished between culture as a variable and culture as a root metaphor. Researchers who saw culture as a variable, something an organisation '<u>has</u>', drew on a traditional objectivist, functionalist view of social reality and often used the concept of culture as something to be manipulated, a way of improving performance. Hatch (1997) described the objectivist epistemology as viewing culture from outside, as an independent observer, likely to use a consultant/ clinical analysis (Schein, 1992) or even quantitative methods (Hofstede et al., 1990). In contrast, researchers who saw culture as a root metaphor approached organisations as if they '<u>are</u>' cultures and used a subjectivist/ interpretive approach in which culture was viewed as a point of entry in gaining a broader understanding of life and work (Alvesson, 1993; Hatch, 1993; Smircich, 1983a). The subjectivist approach involved discovering how insiders experienced and constructed their world and placed value on their meanings and interpretations. Anthropologists referred to this as the "native view", usually using an ethnographic methodology. These approaches need not be seen as mutually exclusive, and have been identified as often being found inside the same study (Alvesson, 1993) where understanding and reflection gained by an interpretive approach may precede the functionalist objective of effective action.

The importance of an interpretive approach was implicit in Spradley's description (1979) of observable behaviours and artefacts as "the thin surface of a deep lake" with the object of a cultural study being to uncover the cultural knowledge that is used by participants to interpret experience and generate behaviour.

As indicated earlier, I selected the model proposed by Edgar Schein, (1985,1992) as the theoretical framework to guide this study. An influential conceptual framework for analysing and intervening in the culture of organisations, it has served as a departure point for many organisational theorists. Schein defined culture as:

> *...a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems* *Schein, 1992, p. 12*

Schein postulated that there were three essential preconditions for any group to be described as having a culture; firstly, that the group had a history of shared experience, secondly, that there was some stability of membership in the group, and thirdly, that for a newcomer a process of learning took place at a conceptual level. I briefly discuss each of these.

First, the concept of "sharing", be it shared meanings, norms, assumptions, values or knowledge was central throughout all studies and discussions of culture. Observable phenomena that illustrate the notion of things held in common or shared among a group could be seen to include: observed behavioural patterns, language including jargon, style of dress, office layouts, traditional rituals, recognised pathways to promotion, and an understanding of 'the way we do things round here'.

Hatch (1997, p.206) commented that although the notion of sharing was central to concepts of culture, shared meanings may be elusive. Instead key symbols might be widely recognised by participants but associated with a multitude of meanings and interpretations. For this reason "sharing" used in the context of culture may mean that whilst each member participates in and contributes to the broad patterns of culture, the contributions and experiences of individual members of the culture are not identical. Even members of a family do not always think the same.

Second, stability of membership of a group refers to members of an organisation, institution or club who had shared in the formation and successful growth of their group or arising in functional groups in an organisation who share similar educational backgrounds and organisational tasks, including shared experiences of success or hardship (van Maanen & Barley, 1984). Critical to stability is the notion that members of the culture were likely to have a history of facing similar problems and adopting a common set of understandings for enacting proper and consensually approved behaviour (van Maanen & Barley, 1985).

Third, one of the major activities of any new member when she entered a new group was to decipher the norms and assumptions that were operating. The reactions of long time members provided a teaching process often quite implicit and unsystematic. The concept of learning or enculturation is a recurring theme in the literature. Schein (1992) saw the process by which the accumulated shared learning of a given group, which covered behavioural, emotional and cognitive elements, was remembered and passed on to new members as an essential component of culture.

### 2.3.2 Schein's model of culture

Schein (1985,1992) proposed that culture was often associated with the visible behaviours and practices enacted by the members of a culture, verbal manifestations seen in written and spoken language and rituals, ceremonies and the tangible physical objects. These visible, tangible and audible manifestations were the most accessible elements of a culture and were known as artefacts, but the essence or core of a culture was recognised as their underlying and invisible source.

Schein's model, shown in Figure 1.1 (p.17), distinguished three levels of analysis, where the term level referred to the degree to which the cultural phenomenon is observable. The first level was the tangible, overt manifestations that one can see and feel. Underneath, at the second level, lay values and behavioural norms, and at the third, deepest, level lay the unconscious, basic beliefs and assumptions that Schein defined as the essence of culture.

Using this model, it was suggested by Schein that close observation of the behaviours, practices and other artefacts leads to an understanding of the values and norms that act as day-to-day operating principles. Values are the social principles, goals and standards held within a culture to have intrinsic worth. They define what a person cares about, and how judgements are made. Although invisible and intangible, it has been suggested that values can be recognised fairly easily, particularly when an outsider or marginal member of a group challenges them in some way (Hatch, 1997). Norms, closely associated with values, are the unwritten rules that allow members of a culture to know what is expected of them in a wide variety of situations. Trompenaars (1993) suggested that a culture could be viewed as relatively stable when the norms reflect the values of the group.

According to Schein’s theory, members of a culture hold values and conform to cultural norms because their underlying beliefs and assumptions nurture and support these norms and values. These underlying beliefs and assumptions exist outside ordinary awareness and are, for the most part, inaccessible to consciousness. They represent however, what members believe to be reality and thereby influence what members perceive and how they think and feel. Schein (1991) defined seven dimensions that must be resolved by every culture and claimed that identifying how a culture resolves each of these defines the culture’s core assumptions. These dimensions, around which basic assumptions form were: the nature of human nature, the organisation’s relationship to its environment, the nature of reality and truth, the nature of time, the nature of human activity, the nature of human relationships and homogeneity vs diversity.

From the point of view of Schein’s model, culture appeared to be driven from the core, the depths of unconscious assumptions, to values and norms and then to the surface, where numerous behaviours and practices are observed. As shown in Figure 1.1 however, the arrows in the model pointed both ways. He suggested that changes in leadership, membership, the pressures of economic factors, and other external factors may result in changes at the level of practice and behaviour. If these changes settled into new stable patterns, which a group adopted, it was likely that new shared values or beliefs would become part of the culture and ultimately could lead to new shared assumptions. The model is therefore dynamic.

### 2.3.3 Critiques of Schein's model

Later authors have challenged or critiqued Schein's model in a number of ways that are relevant to this study. Focusing especially on the concept of subcultures, van Maanen and Barley (1985) disputed the Schein assumption of an organisational culture as unitary or integrated, and envisaged small cultures (i.e. the subcultures), each a consistent, consensual, stable whole, existing within the same organisation. They defined a subculture as:

> *…a subset of an organization's members who interact regularly with one another, identify themselves as a distinct group within the organization, share a set of problems commonly defined to be the problems of all, and routinely take action on the basis of collective understandings unique to the group.* *Van Maanen & Barley, 1985, p.38*

Van Maanen and Barley made two observations about human nature that explained the occurrence of subcultures; firstly, psychological studies have shown that people tend to be attracted to others they see as like themselves, and, secondly, when individuals regularly interact over time, a cohesive group is likely to form. I noted the similarity to Gaff and Wilson's (1971) description, mentioned earlier (2.2.4), of how disciplinary cultures formed. It seemed evident that academic disciplines could be viewed as subcultures residing within the university culture, which itself could be thought of as a subculture of the local, societal culture. The differentiated perspective, or subcultural point of view, suggested by van Maanen and Barley was seen as leading on a continuum to even greater complexity in the fragmented perspective (Martin, 1992). According to Martin the fragmented perspective focuses on confusions, paradoxes, ambiguity and unknowns, with no stable organisation-wide or subcultural consensus.

In a collection of work from each of these three perspectives, Frost, Moore, Louis, Lundberg and Martin (1991) argued that for a complete understanding of any culture, it was probably useful to consider all three perspectives. The integrated perspective would identify all that was common across the organisation, the differentiated perspective would identify those groupings that operated as subcultures within the wider whole and the fragmented perspective would make clear any ambiguities and contradictions. My interpretation of Hatch's (1997) illustration of these three perspectives is shown in Figure 2.1.

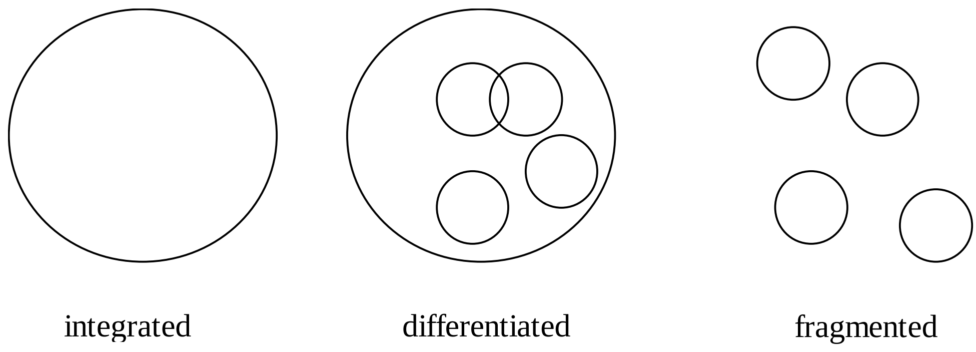


Figure 2.1 Representation of the integrated, differentiated and fragmented perspectives of culture (adapted from Hatch, 1997, p. 226)

Hatch (1993) proposed a "dynamic model of culture" that was based on Schein's model but focused not on the elements of assumptions, values and artefacts, but on the processes linking these elements. Hatch aimed to highlight the processes by which artefacts and symbols were created in the context of organisational values and assumptions and also how values and assumptions could be maintained and altered by using artefacts and symbols. Alvesson (1993) suggested that understanding culture from the interpretive approach as "webs of significance" or as "networks of shared meanings" provided valuable insights but the pragmatic perspective of the functionalist approach was also useful and both approaches could therefore be seen as valid and beneficial inside the same cultural study.

So, although Schein's original model may be an oversimplification, it has been promoted (Hatch, 1997) as serving an important role in guiding empirical research and generating theory, especially when combined with ideas drawn from the interpretive perspective.

The literature I have discussed in this section supported the use of Schein's conceptual framework combined with an interpretivist perspective for my study. In considering the impact of the culture of engineering education on the participation of women, I saw it as necessary to not only define the dimensions or features of this culture and any subcultures using an objective/functionalist perspective, but also to make visible, using a subjective/interpretive perspective, from the lived experience of its participants, how this culture is learned and enacted.

## 2.4 Gender

Although the problem my study seeks to ultimately address is the low participation by women in engineering education, I have sought to shift from a focus on difference and duality implicit in the language of "women" and "men" in engineering, to one of "gender" with the aim of recognising the potential for commonality, and the dynamic, ongoing changes in meaning that the term "gender" allows. In this section I review the literature relating to gender and gendered cultures to clarify the way this literature has informed my thinking and subsequent perspective.

The term "gender" has come to be distinguished from "sex" in such a way that "gender" is now widely used, to refer to the socially constructed features and attributes which are usually associated with one or other of the sexes (Gilbert, 1996). According to West and Zimmerman (1991) gender is "the activity of managing situated conduct in the light of normative conceptions of attitudes and activities appropriate for one's sex category"(p.14). In other words, they saw a person's gender as "not simply an aspect of what one is but more fundamentally what one does, and does recurrently, in interaction with others" (p.27). Contemporary theories of masculinity, particularly those of Connell (1995) and Segal (1990), stress the active and dynamic nature of gender construction. This ongoing construction of a gender identity, as something that develops and changes in response to circumstances, has been widely recognised as an inextricable part of an individual's sense of who they are (Davies, 1989; Lewis et al., 1998; Thomas, 1990; West & Zimmerman, 1991).

I saw the research involving gender and disciplinary fields as, in general, conceptualised on the basis of the assumption of 'gender' as a concrete, definable category, which was then operationalised as an independent variable, in the search for quantifiable effects. The focus has usually been on identifying the circumstances and extent to which men and women (or girls and boys) differed in abilities, attitudes and other attributes, and how social processes and structures affected them.

The treatment of gender as an independent fixed variable has been identified as problematic in a variety of disciplinary areas such as science (Gilbert, 1996), organisational studies (Alvesson & Billing, 1997), mathematics (Day, 1996) and engineering (Stonyer, 1996). Treating gender as a variable (and/or attribute of individual human beings) was seen to imply, firstly, the assumption that it was an essential invariant characteristic, and secondly that all of the members of a particular gender have certain important features in common. The 'invariance' of gender has certainly been disputed and Yeatman (1993) among others, perceived gender as constantly being negotiated within culture; dynamic, not static and therefore subject to processes within society in which it is either changing or able to be changed. Gendered practices were different a decade ago and will be different in the future. Even more disputable was the treatment of any gender as a unitary category. Neither women nor men are a homogeneous group, but differ in terms of factors such as class, ethnicity, sexual orientation and culture – but these factors were rendered invisible in research which focused on gender as difference. A special danger seen by Gilbert (1996) was the speed with which ideas, such as that all members of a gender 'group' were interested in the same things or had the same preferred learning styles, became part of the folklore and therefore difficult to shift.

Gender has been seen as one of the most powerful of symbols, encapsulating all the symbols that a culture elaborates to account for biological difference. Gherardi (1994) described masculinity and femininity as "symbolic universes of meaning" (p.591) which were derived from an implicit and explicit opposition. Affirming one entailed denying of the other, if perceived as antithetical to it. The Collins English dictionary (1994) defines masculinity as "possessing qualities or characteristics considered typical of or appropriate to a man, manly", but provides as a second meaning "unwomanly, not feminine". Masculinity presupposes femininity, which again presupposes masculinity.

As abstract attributes or ideals, both masculine and feminine sets of traits are supposed to be capable of characterising both women and men (even though the mix of characteristics might be seen as differing between the genders) (Alvesson & Billing, 1992). Typically, however, qualities and attributes have become deeply entrenched as stereotypes in our understandings of masculinity and femininity:

> *Masculinity has been defined, for example, as rational, analytical, achievement oriented, problem-solving, independent, self reliant and resourceful. Femininity, on the other hand has been defined as receptive, nurturant, empathetic, intuitive, emotional, supportive and submissive.* *Forisha, 1981 cited by Alvesson & Billing, 1992, p. 75*

Until relatively recently, gender studies have been dominated by feminism where feminism is historically connected to the struggle for women's economic, social and political independence. A considerable body of feminist scholarship now exists which demonstrates the persistence, across 2000 years of philosophy, of the construction of the category "woman" as whatever is "not man", as the basis on which the category man is possible. This defining of woman as Other, or the Second Sex has been seen (Gherardi, 1994) as placing the attributes of femininity – caring, compassionate, emotional, willingness to please others – in a subordinate relationship and privileging the qualities and attributes seen as masculine.

This "privileging" has been attributed to the way much of Western thought tends to be organised in terms of binaries or dualities – with "what a thing is" and "what it is not" being two halves of a binary concept. Lloyd (1993) saw many of these dualities as emanating from as far back as the Pythagorean table of opposites formulated in the sixth century BC, in which femaleness was explicitly linked to the formless and unbounded, the vague and indeterminate and maleness linked to the bounded, the precise and clearly determined. Other philosophers including Schiebinger (1999) have provided examples such as: reason as opposed to feeling, culture to nature, objective to subjective, masculine to feminine, and argued that the two parts of the binary are never equally valued. All of the first halves (or left sides) have come to be associated with each other in such a way that the association appears to be a natural one and rationality, objectivity, culture and masculinity appear to be naturally co-occurring.

Writing of their experiences as women in the male dominated field of engineering, Mitchell and Baillie (1998) advocated the approach suggested by Capra (1982). Capra discussed the ancient Chinese concept of yin and yang values, often seen as polar opposites but more correctly poles of a whole, as limits for the cycles of change. In modern Western culture, yin has been strongly associated with femininity, passivity and emotion, and yang with masculinity, activity and rationality, with all the value judgements inherent in those terms. Capra saw it as valuable to realise that it was the view of ancient Chinese culture that what was good was not yin or yang alone, but the dynamic balance between the two. All people, both men and women, could therefore be viewed as experiencing yin and yang phases with the reality being continual flow and change.

This concept of flow between two poles, rather than mutual exclusion matches well with Parker's proposal (1997) that many of the dualisms so inherent in discussions of gender and science could be viewed as complementary rather than oppositional. She recognised that the use of dualisms may have provided one kind of tool for describing the world, but in practice dualisms were used more often as self-evident truths with predictive and definitional significance rather than as ends of a continuum. Her concern within education was that, if dualisms such as "science" and "not science" were linked with "masculine" and "feminine", then the notion of mutually exclusive poles could be seen as excluding women from science. Using the idea of complementarity, she suggested that dualisms could be expressed using the words "as well as" instead of "rather than". So, "masculine rather than feminine" would become "masculine as well as feminine", implying the possibility of holding both positions, albeit not simultaneously.

The idea that people have both masculine and feminine characteristics and can be described in terms of the relative balance of these has parallels in the wide literature on psychological androgyny. This psychological theory spawned by the work of Bem (1974, cited in Newton, 1987) argued that masculinity and femininity are not opposites but independent dimensions. Bem's theories have been used by those examining the participation of women in non-traditional areas such as engineering (Clarey & Sanford, 1982; Newton, 1987). Newton's study revealed that women studying to be engineering technicians saw themselves as having both strong feminine attributes and strong masculine attributes, a suggestion which resonated with Kivell (1998), the first woman president of the Institution of Professional Engineers New Zealand.

The consideration of gender functioning as a symbol or metaphor, rather than as an attribute of individuals (an independent variable) has been viewed as offering a productive area of research, in order to see how gender is constructed and reconstructed (Alvesson & Billing, 1992; Gherardi, 1994; Gilbert, 1996) within organisations and educational institutions. It has been suggested that such studies might provide explanations of how gender is being ‘created’ by means of language, patterns of interaction and social practice. Questions such as: “[H]ow can ideas, values, actions and practices be interpreted in terms of masculinities/femininities, carrying male and female values and meanings?” and “[D]o any kinds of masculinities and femininities dominate, and if there is not hegemony, how do they interact?” have been identified as needing answering for a clear picture of the cultural dynamics operating in specified situations (Alvesson & Billing, 1997; McLean et al., 1997).

It seemed clear to me that gender, with its potential for social construction and changes of meaning, was a key concept for understanding the active and ongoing processes by which students constructed gendered identities, (“do gender”), whilst learning what it meant to be an engineer (“do engineering”) within the framework of a culture that has itself been said to be gendered.

## 2.5 Gender and culture

Studies of cultures and organisations tended to ignore the gender dimension until the 1990s. Even currently, few studies of higher education take gender into account except those explicitly addressing gender issues as research questions (Acker & Piper, 1984; Parker, Butorac, Currie, Harris, Pears, & Thiele, 1997; Thomas, 1990). Becher (1989) did not consider issues of gender in his initial study of academic “tribes”, but commented that if he were to conduct his study again he would “want to build in some more systematic allowance for gender” (p. 179). Trowler (1998) recognised the importance of foregrounding gender issues, and argued that the norms, values and attitudes associated with gender are an extremely important part of the cultural flow within and through higher education institutions. In the second edition of his 1989 book, co-authored with Trowler, Becher wrote of the gendering of some disciplines (Becher & Trowler, 2001) particularly with respect to status and power.

In recent years, the interaction of gender with the culture of higher education and other organisations has received more attention, and the literature reveals that the terms “gender” or “gendered” have been recognised as applicable to cultures (Cartwright & Gale, 1995). In seeking the relevance of this literature to engineering education I found it useful to use three categories each of which is discussed below:

- “doing gender” – exploring the ways males and females construct appropriate gendered identities within a specific culture;
- gender cultures – the formation of separate masculine and feminine cultures within an overall culture;
- gendered cultures or gendered organisations – where the cultural values, beliefs, behavioural norms would most commonly be aligned with those seen as appropriate for masculinity ( or femininity).

### 2.5.1 Doing gender in a cultural setting

The focus of Gherardi’s work (1994) was on the symbolic nature of gender and how this is played out in particular organisational settings and roles – “doing gender”. Gherardi highlighted the way participants may believe their dress, language and style expresses purely personal tastes and inclinations but that this is coupled with knowledge of what matches and what clashes with the organisation’s style and particular occupational communities inside it. Alvesson and Billing (1997) put forward the idea that the very nature of culture involves assumptions and ideas about appropriate behaviour that are taken for granted. Behaviour assumed to be feminine, was for example, seen as natural and self evident when performed by females, but surprising, odd and unnatural when characterising a man and vice versa. They recognised that “gender is not simply imported into the workplace: gender itself is constructed in part through work” (p.106). I provide an overview of the literature that discusses "doing gender" and the formation of gender identities within the engineering education culture later in this chapter.

### 2.5.2 Gender cultures

The second way gender and culture have been linked, named as "gender cultures", occurs when distinct male and female cultures exist which, although integral to each other, are seen as rigidly bounded within a culture (James & Saville-Smith, 1989). In such a culture, all social relations are structured and understood through concepts of masculinity and femininity.

The influence of national or local cultures on an organisation led Hofstede et al. (1990) to use masculinity as one descriptor of national cultures. A "masculine" national culture referred to the clear separation of gender roles in society and valuing of the work goals of career advancement and earnings, rather than interpersonal relationships, service and the physical environment. In such "masculine" national cultures, Hofstede et al. noted that women were less evident in the professions than in those countries with a more "feminine" national culture.

The Australian and New Zealand national cultures both have their colonial roots in Britain, but differences (both historical and social) have led to distinctive identities. New Zealand has had a variety of studies on aspects of gender within its national culture (e.g. James & Saville-Smith, 1989; Novitz & Willmott, 1989; Phillips, 1996). James and Saville-Smith were emphatic that New Zealand had a culture which was markedly gendered – "the intimate and structural expressions of social life are divided according to gender" (p.7). In such a culture masculinity and femininity were sharply defined.

Phillips (1996) saw the New Zealand national identity as often linked to that of the male and the image of a New Zealander irrevocably tied to rugby, the All Blacks, outstanding sportsmen or explorers such as Sir Edmund Hillary and in more recent times Team New Zealand, the winners in 1995 of the America's Cup. In his book "A Man's Country", which social scientists have described as foregrounding gender relations as a category for understanding New Zealand society, Phillips (1996) presented not only a history of masculinity in one society, but also the structure of the discourse that shaped that masculinity. The heart of this male culture was seen in the past to lie with the “rugged practical bloke” who valued “mateship” and the rituals of drinking. In the nineties, he suggested that NZ masculinity had expanded to include the values of teamwork, self-discipline, modesty, adaptability, and quiet loyalty.

Phillips’ model of NZ masculinity related particularly to the NZ Pakeha (non Maori - usually NZ born European). Novitz and Willmott (1989) believed that a clear national identity was becoming less identifiable due to the increased ethnic diversity arising from immigration and the higher visibility of the indigenous Maori people. However, if “hegemonic” masculinity, as viewed by Connell (1995), was that form of masculinity which claims and sustains a leading position within the culture, then throughout most organisations in New Zealand, and especially in academia, the “hegemonic masculinity” is still recognisably Pakeha. Phillips’ model, in particular, appeared to have relevance for my study. My case study institution was until the mid 1990’s numerically dominated by Pakeha men at both staff and student level.

### 2.5.3 Gendered cultures

It did not seem to be a big step, from the view that distinct male and female cultures existed that limit behaviours, to the view that a culture might itself be gendered. A gendered culture would be one whose values, beliefs, and behavioural norms are most commonly aligned with those seen as appropriate for either masculinity or femininity. The majority of the research and literature around the concept of “gendered cultures” has come from the feminist critique, which has been concerned with illuminating the nature of power relations and links with cultures deemed to be “masculine”. As Capra (1982) reminded us, for the past three thousand years the patriarchal nature of Western civilisation has been all-pervasive. It has influenced our most basic ideas about human nature, determined what part women shall or shall not play, and everywhere subsumed the female as subordinate to the male.

Higher education has been named a gendered culture (Baker & Fogarty, 1993; Cox, 1995). Our universities assume the norm of modern Western values, and as is commonly recognised, those in power are usually white and male. Parker et al. (1997) provided evidence from a number of studies that females and males in tertiary institutions operate from different value bases and that the values of institutions tend to be more in tune with the typical male value base. They argued that the most valued activities in universities were those which reflected male patterns of socialisation – individualist rather than collective, competitive rather than co-operative, based on power differentials rather than egalitarian, and linked to expert authority rather than collegial support. Eveline (1994) reconstructed the discourse of "women's disadvantage" within these cultures to one of "men's advantage". This shift in standpoint was supported by Parker et al., who believed that this gendering of the organisational culture had entered the very logic of the university system and rendered the male advantage invisible.

Disciplinary cultures can also be viewed as gendered. It is almost a cliché to say that science is associated with masculinity and arts with femininity and as Keller (cited in Thomas, 1990) so clearly expressed "to both scientists and their public, scientific thought is male thought, in ways that painting and writing – also largely performed by men – never have been" (p.7).

Not only have some subject areas been considered more suitable for men than women (and vice versa), but those subjects in themselves have seemed to embody qualities that are closely linked to our ideas about masculinity and femininity. Thomas (1990) provided many examples of the language used by physics students in speaking of their discipline compared to arts disciplines. Words such as "hard", "difficult" and "logical", immediately put in opposition "soft", "easy" and "intuitive" and their gendered implications. It should also be noted that the link between masculinity, status and usefulness of the physical sciences and engineering, and the low status and links with femininity afforded by some to arts degrees has been frequently noted (Lewis et al. 1998; Schiebinger, 1999; Seymour & Hewitt, 1997).

## 2.6 Gender and the Culture of Engineering Education

*The culture will not be changed merely by the inclusion of more women. Proposed solutions centre on addressing both sides of conflict between feminine gender identity and the masculine culture of SET (Science, Engineering and Technology)* *Cronin & Roger, 1999, p.653*

In this section I review the literature linking the interaction of gender and the culture of engineering education. Initially I examine the theoretical perspectives from which the "problem" and "solutions" of the under-representation of women in engineering education have been approached. I then follow by, firstly, critiquing the literature dealing with "doing gender", how females and males construct appropriate gender identities within engineering education, and secondly, critiquing that research which has focused on cultural values and norms that have led to the identification of engineering education as a "gendered culture".

### 2.6.1 Theoretical perspectives

I discussed in Chapter 1 the background to the framing of the problem of women's under-representation, and the limitations of locating that problem in women's schooling, socialisation, career awareness and image of engineering. It has been suggested that the plateauing of participation is giving strong indications that the successful run of these liberal policies has finished (Byrne, 1993; Lewis & Harris, 1995). Concern has also been expressed that a perception of higher visibility of women in faculties has carried the implication that there are no longer any barriers to women's participation in engineering (Cronin & Roger, 1999).

Female participation in engineering education in Australia (Appendix 1), New Zealand (Appendix 2) and internationally, particularly in many subdisciplines of engineering, is still well below the level of 30% that Byrne (1993, p. 13) identified as sex-normal for the minority sex. Byrne (1993) agreed with Lantz's (1982) proposal that "once a certain number of a population is present, recruitment and retention of that population becomes a self sustaining and self perpetuating system" (p. 731). Whereas Lantz expected a level of 15- 20% to be the critical threshold at which the enrolment of women would be seen as normal and would continue to be substantial without affirmative action, Byrne viewed the critical mass level as more likely to be around the “sex-normal” level of 30%.

In the 1990s, theorists, women in engineering advocates, and increasingly engineers, have been advocating a shift in the way that women’s under-representation in engineering is understood and explained (Carter, 1994). Access and support initiatives have continued, but it was recognised internationally that, for long-term improvement in participation, change would be needed at organisational and cultural levels.

The data Byrne had gathered as part of the University of Queensland WISTA project in the 1980s (Byrne, 1993) provided the first glimpse in the local arena of the widely disparate female enrolment and progression patterns found not only in different scientific and engineering disciplines, but also between institutions. She coined the term “institutional ecology” to symbolise the role the institution (an ecosystem) played in the adaptation of new women students (organisms). Most importantly, this work recognised that, although factors outside institutions, such as schooling and social conditioning, did influence enrolment and progression, they could not account for the differential participation reported on and the focus should shift to the learning environment itself.

An early, much quoted paper from the USA (Hall & Sandler, 1982) looked at the learning environment and the subtle, and not so subtle, ways that men and women are treated differently in college classrooms. Their hypothesis was that, for many women, these classrooms provided a “chilly climate”. Although it was hoped that no one student or institution had all the characteristics mentioned, there was wide-spread recognition for many of the issues mentioned. A considerable weight of empirical (Brainard, Staffin-Metz & Gillmore, 1999; Collins, Bayer& Hirschfield, 1997) and qualitative {Bergvall et al., 1994; Copeland, 1995; Lewis, 1995) evidence has confirmed that some female students continue to experience the learning environment in engineering education as a chilly climate. It was recognised that there was no predictability to this chilly climate and that it could vary from one year to another, or from one class to another, but when it did occur young women were seen to either leave the course or experience learning obstacles that affected their success (Lewis, 1995).

Another component in the discourse was the linking of theories about the construction of knowledge and the possibility that men and women had different ways of knowing (Belenky, Clinch, Goldberger & Tarule, 1986; Gilligan, 1982) with the continued under-representation of women in engineering (Roberts & Lewis, 1996). Belenky et al. (1986) hypothesised that more women than men may be "connected knowers" (where the relationship between the self and the knowledge is important – being able to link topic to personal experience) and that more men than women operated as "separate knowers". Separate knowing, they regarded as more like the traditional, objective, rule-seeking ways of evaluating, proving or disproving truth – reflected in most secondary and higher education curricula and teaching, particularly physics and engineering. Male students attracted to science and engineering have been identified as usually more comfortable with the disconnection between theory and context (Harding, 1986) whereas females as Rosser remarked:

> *…..females are more likely to feel comfortable in approaching problems and laboratory experiments if they understand the relationship of the particular problem or experiment to the broader context of the bigger problem of which this solution may be a small part.*
>
> *Rosser, 1995, p.13*

In contrast to the studies of Belenky et al. and Gilligan, which used only female participants, Baxter Magolda (1992) worked with male and female students over a five-year longitudinal study. In her study, Baxter Magolda identified four ways of knowing, differentiated by the extent to which knowledge was viewed as absolute, or certain, leading to particular expectations of the learner, peers and instructor in learning settings. She named these Absolute, Transitional, Independent and Contextual Knowing. Within each of these four ways of knowing, experienced by both female and male students, Baxter Magolda provided evidence that a relational approach to learning tended to be adopted by more women and an abstract approach by more men. Baxter Magolda commented on her apprehensions of the dichotomous generalisations around gendered ways of knowing which appeared to have been based on the work of Belenky and Gilligan, despite the latter's mention of overlap and trends. Baxter Magolda used the analogy of "prevailing winds" to explain the fluidity of patterns of knowing which were gender-related but not employed exclusively by one gender.

Two models have been proposed to frame the theoretical shift referred to earlier. The first was Lewis's adaptation of the Schuster and van Dyne (1985) curriculum change model (cited in Harris & Learmont, 1992) as shown in Figure 2.2. Lewis regarded curriculum change models as providing an important reference point for the analysis of gender and science strategies and programs, as they depicted the incorporation of women into engineering education as a chronological process with identifiable phases.

**Level**

1. No notice taken of lack of females
2. Absence of females noted: women seen as an untapped pool of talent and encouraged to enter engineering to have better careers
3. Exploring why lack of females in engineering Issues with access examined, female friendly promotional material and role modelling
4. Analysis of female experience in engineering Issues of success and retention, course content, assumed knowledge, assessment practices
5. Challenging the paradigm – changing the engineering curriculum and learning environment – to include and validate women's interests and learning styles
6. The transformed gender balanced curriculum

**CHANGING FEMALES**

**CHANGING THE SYSTEM**

Figure 2.2 Lewis model (adapted from Schuster and van Dyne (1985)) (cited in Harris & Learmont, 1992)

Until the mid 1990s the majority of practice, research and theorising, Lewis suggested, had been based at levels 3 and 4 on her model, focusing on access and participation. Much of the theory and strategies being applied to engineering education she saw as coming from the huge literature generated in the 1980s and early 1990s around women's and girls' participation in mathematics and science education. Comprehensive summaries of this literature are contained in Byrne (1993), Kahle (1988), Parker, Rennie & Harding, (1996) and GASAT conference proceedings (reviewed in Vlaeminke et al., 1995).

Strategies at level 5 on Lewis's model, where engineering education was challenged, started to appear in the mid 1990s in recognition that not only the content, the teaching methods and styles, and criteria for success in engineering were male-defined, but that the knowledge itself could be seen as reflecting a bias towards male cognitive styles and preferred "ways of knowing" (McIlwee & Robinson, 1992; Roberts & Lewis, 1996).

These strategies have included curricular and pedagogical changes, as well as training to increase the awareness of teaching staff. Gender inclusive curricula and teaching guidelines have been produced in Australia (Ayre et al., 1998; Moxham & Roberts, 1995) the USA (NECUSE, 1996) and the UK (Cronin et al., 1999; CuWaT, 1998). These curricula and guidelines recommended strategies and practices that included the interests, prior experiences and preferred learning and assessment styles of female students. They recommended broadening the range of teaching and learning methods, encouraging student interaction, teaching teamwork skills and making more explicit links between theoretical and practical learning. It has been suggested that these strategies not only provide a better educational opportunity for female students but also for the increasingly diverse student population generally (Ayre et al., 1998; Cronin & Roger, 1999). Stonyer (2001) sounded a warning when she identified that curriculum change with an emphasis on gender inclusivity can be perceived as firstly, softening or diluting engineering, and secondly, implying women's inability to engage with the predominantly masculine learning styles and concepts embodied in traditional curricula. She believed that whilst a gender-inclusive focus may aim at equity for women, it may continue to implicitly construct women as disadvantaged in learning.

A second conceptual framework for theorising the progression of approaches to women's under-representation in science, engineering and technology has been proposed by Cronin and Roger (1999). This framework located five theoretical positions according to their assumptions about science, technology and gender and linked each of them to feminist epistemologies of science. Although it bore similarities to the Lewis model, this framework moved beyond considering women as a unitary category to consideration of the links between gender identities and the culture of science, engineering and technology (SET).

The 5 positions proposed by Cronin and Roger were:

1. Foster public understanding of SET
2. Recognise SET's economic contribution
3. Promote equality of opportunity
4. Subject SET to critical analysis
5. Change SET culture

At positions 1 and 2 gender was not central to the analysis. By contrast, position 3 was linked by Cronin and Roger to that of feminist empiricism, where the sex / gender system which structured inequalities of virtually all social life was problematised but left untouched the methods of science. As I mentioned in Chapter 1, this liberal feminist approach, inherent in the majority of interventions, has been criticised for its acceptance of existing norms and standards, and failure to subject science, engineering and technology to critical analysis.

Theories at position 4 on this framework proposed that women's under-representation was considered to be largely the result of inherent bias in the social construction of science, engineering and technology. This position was linked to that of feminist standpoint epistemology, which supports the view that the subordinated position of women offers them a perspective different from, and more complete than, that of males. Cronin and Roger saw this position as not aiming simply to substitute "woman centred" for "man centred" but rather to provide a more accurate understanding of the entire world and leading on to Position 5 which advocated a change to the overall culture of science, engineering and technology.

Position 5 was seen by Cronin and Roger to have theorising based on a critical understanding of the interplay between the social construction of engineering and gender. They recognised the historical and cultural construction of technology (Wajcman, 1991) as masculine and the impact this has had on stereotypical gender identities: especially masculinity constructed through technical competence and femininity linked to lack of technical competence (McIlwee & Robinson, 1992). The perceived conflict between feminine gender identity and the masculine culture of SET (McIlwee & Robinson, 1992; Wajcman, 1991) was seen as explaining the persistent gender imbalance in engineering, computing and physics which are perceived as the most masculine or “hard” sciences (Schiebinger, 1999; Thomas, 1990). Cronin and Roger emphasised that the culture would not automatically change by the inclusion of more women, but strategies that addressed and challenged both sides of the conflict between feminine gender identity and the masculine culture of engineering would be of prime importance.

This last statement resonated strongly with my hypothesis that to make culture change possible, theory must be developed that will underpin strategies such as those put forward by Cronin and Roger. Application of this theory would make visible the interplay between the social construction and cultural assumptions about gender and gendered identities with the cultural norms, values and assumptions of engineering education.

Earlier, in sections 2.3, 2.4 and 2.5 of this chapter, I discussed the literature and understandings which informed my use of the terms “culture”, “gender” and “gendered culture”. I also provided, in section 2.2, an overview of the behaviours, practices and norms that have been commonly associated with engineering education. I will now look at the literature which has conceptualised the formation of gender identities within engineering education – “doing gender” whilst “doing engineering” – which will be followed by a summary of the research that has led to the view of engineering education as a gendered, i.e. masculine, culture.

### 2.6.2 “Doing gender – doing engineering”

The cohesiveness and self contained nature of engineering schools has been seen to result in a social and academic environment, with an often intense and demanding curriculum, in which close interaction and “fit” is recognised as important (Lewis, 1995). Phelan, Davidson, and Cao (1991) used the terms “multiple worlds” and “border crossings” to describe the boundaries of family, peer and institutional culture which a student may be required to negotiate using appropriate cultural knowledge of values, beliefs and expectations. Smooth “border crossings” to the university and engineering cultures, have been viewed as easier if the personal cultural values they bring are similar to those they find in the institution (Clewell & Ginorio, 1996) and when boundaries and likely obstacles are recognised (Hodson, 2001). Engineering students arrive at university with a background of gendered identity formation, and notions of appropriate masculinities and femininities learned from home, schooling, church and even the media. As Lewis et al. (1998) stated, “people’s identity positions are strategic… as they construct, change and deploy their notions of who they are in order to achieve their chosen goals”(p. 61).

Several authors have identified a limited range of behavioural responses available for a female student in the male dominated setting of engineering education. O’Regan (1996) observed that some women sought to become invisible, some experienced feelings of inadequacy and shame and others felt the burden of being a banner bearer. McLean et al. (1997) saw female students responding to the environment in three main ways – they could become “just one of the boys” and therefore invisible as a female, adopt a traditional femininity (“the hair spray girls”), or adopt a feminist position. This latter position was named “the F word”, because of the very negative response from male students to female students perceived to adopt this position.

Stonyer (1996) explored engineering education at the U of A, in the early 1990s, using discourse theory to make visible possible subjectivities within engineering education. She found that the subjectivities, or positions that engineering education encouraged students to take up, included the roles of “scientist”, “the servant” and the “well rounded engineer”. Each of these was an engineering identity, developed as students learned what it was to “do engineering” and it was argued that these were not only the “normal” positions, but clearly gendered as masculine. Stonyer was particularly interested in how gender was imprinted on these subjectivities, and she concluded that although women students expressed their compliance with and loyalty to these positions, particularly those of “servant” and “well-rounded engineer”, their stories indicated that they did not see their positioning in these subjectivities as being “as of right”. She identified that women students in her study simultaneously constructed gendered engineering identities for themselves of “equal woman”, “the feminist”, and “the disadvantaged Other” locating them on the margins of engineering education rather than at the centre.

The “equal women” saw themselves as being stronger, more confident because of their engineering education but acknowledged that the best they could achieve was the status of “almost guys”. Those students who Stonyer classified as “feminists” found difficulty with moving outside the boundaries of acceptable behaviour for a woman and were more likely to debate or challenge behaviours and practices on grounds such as “behaviour unbecoming to a member of a professional body” (p. 109). Such students experienced a contradiction between femininity and feminism. Stonyer’s identity of the “disadvantaged Other” was not mentioned in previous studies. This category of student, Stonyer proposed, successfully graduated but struggled with being recognised by themselves and others as legitimately knowledgeable engineers.

How students acquire the existing culture and to what extent students whose niche in the culture was marginal or non-existent (e.g. women) could manoeuvre the culture was the main thrust of Tonso’s work (1997, 1999). She saw enculturation as a complex procedure, with the adoption of some facets and adaptation of others, as men and women sought to understand their setting. Whereas Stonyer had focused on ways in which students formed engineering identities, Tonso was concerned with how students fitted into already existing forms of cultural belonging.

In close observation of design classrooms, where real-life practices were modelled, Tonso proposed that belonging involved a privileging of one set of understandings and behaviours. Some forms of manhood (competitive, exploitative, academic-achiever or social climber) were observed to hold sway over other forms (collaborative, respectful, salt-of-the-earth) and additional forms of manhood (sensitive, feeling, non-combative) did not belong at all. Success in terms of grades and job offers was observed as more likely to go to those from the higher status, privileged cultural identities even when behind-the-scenes observation clearly demonstrated a lack of engineering capability.

Alternative views were provided by other authors who focused on engineering students’ positive perceptions of themselves as women in engineering. A critique of the Byrne institutional ecology model given by O’Regan (1996) was that this model “implicitly ascribed young women as passive, simple creatures who moved without knowledge or consent into possibly hostile environments in which they may flourish or perish depending on factors over which they have no control" (p. 617). Refuting this "victim" role, O'Regan described women as "powerful beings", Copeland (1995) saw them as "strong and intelligent" and Henwood recognised (1996) that young women knowingly chose to go into engineering, linking that choice to pride in doing a high status job, "man's work". Pride in being able to put up with difficult conditions (Jolly, 1996), denying difference from male students (Copeland, 1995; Henwood, 1998) and tolerance of men's hostility (Henwood, 1996) were responses repeated by female students around the world. It was common for those working with women students to comment that undergraduate women studying in engineering either do not see or do not acknowledge problems with the culture, and are often not supportive of initiatives organised on their behalf (Copeland, 1995; Jolly, 1996; Lewis, 1995) For these students, acknowledging difference was perceived as being "different from men", therefore feminine and somehow inferior to men and all things masculine. Masculinity was perceived as high status and becoming "one of the guys" was seen as desirable.

Identification as a "bit of a tomboy" was viewed by Henwood (1998), as a woman's "attempt to construct herself as different from other women, who remained by definition, weak and unable to cope in a man's world" (p.41). Lips (2000) suggested that women engineering students were "different" to other females in a study conducted at my case study institution in 1999, continuing research from USA and Canada on students' academic self views with respect to their perceptions of their possible future roles. Lips' results (2000) confirmed that female engineering students differed in confidence and estimation of their own abilities to other female students surveyed, both in New Zealand and overseas. She reported that:

> *Women who choose engineering and remain on that path long enough to take senior level courses, have a different sense of their own strengths and possibilities than other college women do. Compared with the women in the other sample, female Engineering students rated themselves more strongly in maths and science abilities and the possibility of further study in a cluster of areas related to powerful careers. They also produced current academic ratings better and more strongly oriented to maths and science than their male counterparts in engineering.* *Lips, 2000, p.n.a.*

Seymour and Hewitt (1997) highlighted “the double bind situation of women who feel they can only win male acceptance on academic terms, by losing it in personal terms” (p.243). They recognised that the problems of belonging and identity were linked, because the qualities women must demonstrate in order to win the right to belong (especially smartness, assertiveness and competitiveness) raised the anxiety that such recognition could only be won at the expense of femininity. In particular, both Seymour and Hewitt (1997) and Holland and Eishenhart (1990) recognised the male-defined and male-confirmed ways that college students ‘learn gender’, or appropriate female identities through extra-curricular, peer-group interactions including romantic heterosexual relationships.

The various roles that female students have been seen to adopt illustrate how strong the influences are for women students to fit into the existing culture, resisting anything that draws attention to them as women engineers rather than simply engineers (Copeland, 1995). The research quoted in this section strongly implied that the dual role of “doing woman” and “doing engineer” was problematic and appeared to reinforce McIlwee and Robinson’s observation that:

> *…they sought acceptance and approval as engineers and… too much identification with women – either of the flighty or feminist variety – would undermine that*
>
> *McIlwee & Robinson, 1992, p. 70*

### 2.6.3 The “masculine” culture of engineering education

The body of literature that has arisen around the notion of engineering education as a masculine culture originated predominantly from women, who with a few exceptions, were neither engineers nor engineering educators. I saw this as unsurprising in the light of comments that, change relating to equity usually arises from those outside the system (Yeatman, 1993), and that, engineers (who had been traditionally male) were not reflective about their profession (Johnston et al., 1995b). The departure points in most studies on the masculine engineering culture are the writings of Hacker (1981), Carter and Kirkup (1990), and McIlwee and Robinson (1992), who all came to their critiques from a social science research background, observing engineering as “outsiders”. More recently, an increasing body of literature has arisen from women whose academic backgrounds allow them to draw simultaneously on their experiences and knowledge of engineering and the humanities. Several of these women have identified their unique positions:

> *I write not just as an engineer but through the various filters that my experience has offered, feminist, legal, environmental and social justice advocacy, technocratic, – My filters provide a particular view of engineering than others I have encountered.*
> *Taylor, 1998 p.313*

> *I saw through my former-engineer "eyes" to understand and appreciate the students' grasp of scientific and engineering knowledge. I used my math and science educator experiences to evaluate the pedagogical limits of current engineering education teaching practices. And simultaneously I watched with my feminist, social science background to follow the flow of data relevant to women's circumstances on the campus, in classrooms and in teams.* *Tonso, 1997, p.9*

> *We have, as engineering academics, explored our own struggles with engineering and our responses to engineering, and the way in which those responses eventually led us to realise the importance of bringing our selves and our values into the way in which we practise engineering.* *Mitchell & Baillie, 1998, p. n.a.*

A rare male voice in this critique was provided by Ford and Ford (1994) who described the engineering profession as "a man's world", and recognised that "engineering itself, its structures and methods, is male gendered because it is constructed out of a male viewpoint with men at its centre" (p.141). Ford and Ford also commented that the masculine norm had become invisible and was therefore hard to challenge, as this norm was seen to be "truth" and any different perspective therefore became invalid.

Hacker, working in the late 1970s and 1980s, was one of the first social scientists to look at the culture of engineering education, seeking to explore the ways the professional identity of engineers was constructed within their education. Hacker not only observed classes and interviewed staff and students. She also enrolled and studied mathematics and statics with engineering students ("I wanted to know what it feels like") over a period of years at two major American institutions and described her experiences and conclusions in a series of papers (Hacker, 1981,1983,1985, 1989,1990).

A notable feature at the first institution she studied was the attraction most faculty had with abstraction, elegance and simplicity (qualities embedded in mathematics) and the pleasure and ease with which they exercised mathematical skills. Not only did she perceive mathematics as dominant throughout the engineering curriculum, but mathematics classes were seen as courses that acted in a role of “winnowing” or “weeding out” – a role that some saw as problematic:

> *…many mathematics and engineering teachers, no less than their students, continue to question the justice or wisdom in allowing mathematics tests and similar criteria to decide who succeeds and who fails in engineering.* *Hacker, 1983, p.48*

Other features she commented on included the use by faculty of womanly terms such as “soft, inaccurate, lacking in rigour, unpredictable, amorphous” (Hacker, 1981 p.345) to describe the social sciences and the use of classroom humour as a way of transmitting key social values alongside technical expertise.

> *An analysis of just one class showed students were encouraged to laugh at, in order of frequency (1) technical incompetence (2) women and to a lesser extent blacks and workers (3) honesty or everyday morality and (4) the body and its functions, through mildly scatological reference* *Hacker, 1981, p.347*

Common to both institutions was the notion that time was inelastic and that to survive one had to “discipline one’s pleasures” and work as a team (“no one made it through on their own”). These notions of “survival” and “discipline” were also evident in the inferences Hacker drew from the early links of engineering and the military to the classroom climate in which professors made difficulty and competition ends in themselves.

On a positive note Hacker described engineering as “shot through with passion and excitement” finding its “most creative outlet in the design of technology”(Hacker, 1989). Despite this passion, she found engineering to be a very constrained and bound culture that she epitomised with the comments:

> *…real engineering was structured to draw and keep students disciplined with a special set of skills, yielding the camaraderie and elitism of in-jokes, private language and delight in abstraction, complexities and the elegance of the simple solution.*
> *Hacker, 1989, p.45*

Hacker’s work was not aimed specifically at addressing the issue of the under-representation of women, but it uncovered aspects of the culture that had profound meaning for women participating in engineering education. She described a “culture of engineering” that stressed the importance of technology over personal relationships; of formal abstract knowledge (particularly complicated mathematics) over inexact humanistic knowledge and ultimately of male over female traits. In particular, she (like others) argued that this culture was based on a mind/body dualism that stressed the superiority of (rational) thought over (bodily) emotions, where rationality was identified with men and emotion with women.

Although Hacker's work has provided many recognisable features for those in academia, I viewed it in the context of both place and time. The observations and experiences on which the research was based were conducted twenty years ago, in two quite specific institutions in America. Essentially, Hacker was describing not "the" culture of engineering, but "a" culture of engineering.

As indicated above, other research of importance to this study was conducted in the early 1990s by Carter and Kirkup, and McIlwee and Robinson. Both studies primarily analysed the professional engineering culture and women's participation in the engineering workforce, although reference was made to engineering education. Carter and Kirkup (1990), as feminists, saw engineering as socially constructed to be masculine, and queried whether it was appropriate to encourage women to become engineers and enter such a profession. At the educational level they concluded, on the basis of interviews with female engineers from the USA and the UK, that "male engineers engage in the process of masculinizing the subject area, and therefore marginalizing women students" (p.67). They also noted, however, that at university, the standards applied for success were mainly academic and less open to bias than the all pervasive male values of the engineering workplace. Carter and Kirkup questioned whether the masculinity of engineering was inevitable or beneficial, and proposed a re-examination of the fundamental assumptions on which engineering has been built. They did not, however, attempt to define these fundamental assumptions or values in ways other than as they related to gender. It was McIlwee and Robinson who provided a theoretically based analysis of professional engineering culture.

McIlwee and Robinson's study (1992) interviewed practising engineers, both male and female, who had graduated from two colleges on the west coast of America. Their investigation of the engineering workplace culture drew on both conflict and interactionist discussions of cultural reproduction. Inherent in the conflict approach was the understanding that power relations within an organisation allow the values of some groups to become dominant and it is these values that are manifested through daily patterns of interaction. McIlwee and Robinson pictured the workplace culture of engineering as consisting of three components:

> *First and most important, it is an ideology that stresses the centrality of technology and of engineers as producers of this technology…*
> *Second, it stresses the acquisition of organisational power as the base of engineering success…*
> *Finally, it requires that interest in technology and organisational power be interactionally 'presented' in an appropriate form – a form closely tied to the male gender role* *McIlwee & Robinson, 1992, p.19*

Culture was seen as manifested in the rituals of day-to-day conformity. To believe in a value or conform to a norm was viewed as meaningful only in so far as it was obvious to others and became obvious in interaction. McIlwee and Robinson concluded that:

> *To be taken as an engineer, is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking and acting male*
> *McIlwee & Robinson, 1992, p.21*

In the role of an engineer, particular importance was placed by McIlwee and Robinson on the image of hands-on competence, expertise as a tinkerer, a fascination with technology and the close links of these images with the male gender role. McIlwee and Robinson did not see the values and norms of the workplace culture as automatically replicated at the educational level. They recognised that in the university environment, the group with the most power to shape the definition of culture was the academic faculty, and as a result the definition of a "good engineer" would emphasise academic over technical skills. Based on their interview data, rather than personal observation and experience, they saw the culture of engineering in the university where academic performance was valued above all else, as quite compatible with the resources of women students.

Both Carter and Kirkup, and McIlwee and Robinson clearly named the culture as "masculine", but did not provide explanations of the ways in which the teaching and learning environment manifested the norms and values of this masculine culture or how those values and norms were constructed and learned by the participants at the educational level. This gap was filled, to some extent by an Australian study of the culture of engineering education, discussed in a series of papers (Lewis et al., 1998; McLean et al., 1997) which built on earlier work aimed at valuing diversity (Copeland, 1995; Mares et al., 1996; Parfitt, Copeland & Lewis, 1996). This research particularly recognised the need for a better understanding of the lived experience of the students within the teaching and learning environment. They stated that their research:

> *… is based on the premise that we need to gain a clearer picture of the existing cultural dynamics within university engineering faculties in order to understand the ways in which these cultural factors perpetuate the under representation of women.*
>
> *McLean et al., 1997, p. 143*

It was recognised by this group that, with the exception of disciplines such as Environmental and Chemical Engineering, women in engineering faculties were usually learning and studying within the collective dynamics of a numerically dominant male group. Their data supported the inference that classroom practices were likely to advantage some students and disadvantage others.

Tonso, also working in the middle of the 1990s, but in the USA, believed that the "ways a masculine discipline is created or maintained in the everyday face-to-face interactions and activities of undergraduate engineering education are not well understood" (Tonso, 1996, p.217). She believed that some women had difficulty with the culture and that these difficulties were a result of "cultural features of engineering that are only rarely open to redefinition by women" (p.217).

In a previous section of this chapter I have commented on identified cultural norms within engineering education, but it is the specifically masculine nature of these cultural norms which is viewed as a major impediment to change (Lewis et al., 1998; Roberts & Lewis, 1996; Seymour & Hewitt, 1997; Tonso, 1996b). The masculinity of the engineering education culture has been viewed as manifested in the following cultural norms.

#### 2.6.3.1 Background skills and experience

Lewis et al. (1998) proposed that background skills and experience shaped success in engineering and determined ways in which women were often compared and contrasted with the norm. Even when they had little connection with real engineering work, hands-on skills, cars and sport were interests seen to be widely represented in the curriculum (Ayre et al., 1998) and provided opportunities for shared communication in peer and lecturer relationships. The presence of these and other masculine topics used in practical examples and as projects for drawing and design were largely invisible to men in engineering, and traditional female interests were actively devalued in comparison (Roberts & Lewis, 1996, p.9).

Hacker (1983) had referred to the prevalence of mathematics in engineering education as "masculinising" the discipline. Byrne (1993) argued that the "masculinising" of mathematics resulted from the effect on learning styles, cognitive development, interests and expectations of the different socialisation and educational experiences of males and females which linked mathematical ability with "sex normal" for males but not for females. These links rather than ability or confidence, she proposed, contributed to the lower female participation in mathematics by senior school levels. Forbes (1999), who considered participation as well as achievement, demonstrated a disparity in mathematical knowledge between male and females in their final years of secondary schooling in New Zealand. Statistical data at secondary level, however, has shown that those females who chose to continue with mathematics performed better than their male counterparts (see Appendix 2 for New Zealand data). Lips ( 2000) study, mentioned earlier in 2.6.2, found that compared to other women and their male peers, female engineering students rated themselves more strongly in maths and science abilities.

#### 2.6.3.2 Valuing of "hard" science

Roberts and Lewis (1996, p.9) recognised that the values of "hard" science, technical knowledge, objectivity, facts and measurable variables have proved useful in engineering in order to analyse systems and provide solutions that work. However, they viewed it as less useful that methodologies and disciplines that attempt to incorporate the complexities of human systems were seen as ‘soft’ and devalued in comparison. The gendering of this hard/soft divide, and the accompanying status afforded to the hard (masculine) has been commented on earlier in this chapter. This gendering has been seen to extend to the discipline level where women’s greater social responsiveness has been viewed as contributing to the tendency for specific engineering disciplines (e.g. environmental) to be gendered as feminine – soft – while other disciplines (such as mechanical engineering) remain masculinised and viewed as “real” engineering (Stonyer, 1996, p.13).

#### *2.6.3.3 Curriculum content and the learning environment*

The Review of Engineering Education (IEAust, 1996) as previously noted, had expressed concern at the heavily content laden curriculum, which had traditionally focussed on technical concerns at the expense of placing these technical concerns in their broader social, human, ethnical, and environmental contexts. Gender inclusive theorists claimed that if the curriculum was presented in a more connected style, incorporating social and environmental concerns, it would attract more women and a greater variety of male students to engineering (Moxham & Roberts, 1995). Ford & Ford (1994) had previously proposed that the current content and teaching style of engineering courses did not necessarily suit young men but that they might be more prepared (or socially conditioned) than young women to put up with those conditions in order to meet their goal (or social expectation) of becoming a member of the engineering profession.

#### *2.6.3.4 Challenge and ordeals – hard masculinity*

As previously discussed, the overwhelming curriculum pace and load appeared to be features of engineering education internationally. The rhetoric of “challenge”, “ordeals” and “survival” in engineering education was recognised by several authors (Hacker, 1985; O’Neal, 1994; Seymour & Hewitt, 1997), as part of the traditional male education process, as “older men introduce younger males to the adult way of knowing” (O’Neal, 1994, p. 1009) and “testing young men to tolerate stress, pain or humiliation with fortitude and self control” (Seymour & Hewitt, 1997, p.260). The undergraduate engineering degree, has been regarded (Lee & Taylor, 1996a) as “valued and construed by many teachers and students as an initiation, a form of rigorous training, to weed out the unfit, as a passport to knowledge”(p. 65).

Seymour and Hewitt identified that the unwritten rules of “challenge” and “proving yourself” were likely to be more familiar to some groups, particularly young white men, as part of their family, educational and sporting background. They saw “proving yourself” as risky and inappropriate for young women, and expressed concern at the “encouragement of young women to enter an institutionalised, possibly international, teaching and learning system which had evolved over a long time period as an approved way to induct young men into the adult fraternity of science, mathematics and engineering” (p.259). By treating male and female students alike, supposedly providing equality, staff were seen as effectively treating women in ways understood by men but not by women.

#### *2.6.3.5 Competitive – influence of grades*

The excessive competitiveness of many engineering education institutions has also been critiqued. The pace, workload and assessment system contribute to a culture where grades are seen as more important than the knowledge used to acquire them or how well the material was understood. Unethical practices were mentioned as “logical and predictable” (Seymour & Hewitt, 1997, p.113) and students’ grades did not always reflect their engineering knowledge and input to projects (Tonso, 1997). This intensely competitive atmosphere has been seen as unhelpful to young women, who often bring patterns of socialisation where co-operation has been valued above winning, but also can provide a problem for men, as they risk being defined as “failures” (Seymour & Hewitt, 1997, p.265).

#### *2.6.3.6 Group behaviour/ identity/ belonging*

Engineering students have been seen as having a strong sense of belonging to a closely knit group with a special and valued identity – often defining themselves as different and superior to other students (Hansen & Godfrey, 1997; McLean et al., 1997). As traditionally male groups, engineering students have demonstrated many aspects of collective male behaviour, designed to make it clear who belonged and who did not. Binge drinking in groups, risk taking, misbehaving and joking were some of the most important of these ‘male-bonding’ rituals recognised and commented on internationally. National and local cultures offered variations, and in small group or individual interactions such generalisations were often found not to apply but recognisable commonalities included:

(i) Mucking around in class – disruptive behaviour

One of the findings of a recent ethnographic study of a first year engineering course in Australia (Jolly, 1996) was the significant degree of mucking about and generally disruptive behaviour in class. McLean et al. (1997) observed that students adopted an attitude that ‘real men’ didn’t take their studies too seriously, therefore misbehaved, and identified that girls were viewed as more conscientious. McLean et al. (1997) viewed disruptive behaviour in class as one feature of engineering culture which clearly distinguished it from other disciplines, particularly those disciplines such as arts which were dominated by females.

(ii) Binge drinking – common in Australia and New Zealand

The reputation of engineering students as beer drinking, unruly “lads” was not seen as a problem by male students in Australian (McLean et al., 1997) and New Zealand studies (Hansen & Godfrey, 1997). In these countries binge drinking and “being able to take it” has been considered as part of the national culture of masculinity (Phillips, 1996) and was seen, in some cases, to be not just condoned, but actually encouraged.

(iii) Joking and the role of humour

Humour and joking were first discussed in an engineering education context by Hacker who noted the use of jokes that “put down” other social groups, including women, as a mechanism of reinforcing the bonding and elitism of the group (Hacker, 1981). Lyman (1987) linked a group joking relationship as an important part of everyday life for young men as a vehicle for creating intimacy or bonding as they negotiated latent tensions and rivalries, both sexual and academic.

> In an Australian study (Copeland, 1995; McLean et al., 1997), sexist joking was usually dealt with by both male and female students by denial of its existence, an attitude of "giving as good as I got" or "it's just a joke", as they sought acceptance in the group. Interview data of either male or female students may not provide accurate evidence of the prevalence of sexist joking, and Tonso (1997) whose study involved close participant observation in informal conditions identified the mild but persistent use of profane language, and semi-sexual double entendres. Sexist jokes, covert or overt, have a particular importance as they not only serve the purpose of joking as a means of defending social order, but, as Lyman (1987) suggested, they act specifically as a mechanism of sustaining the order of gender domination in everyday life.

Both Lewis et al. (1998) and Tonso (1997) acknowledged that while stereotypical, dominant masculine behaviours did manifest themselves strongly when young men were in groups, they did not represent the whole picture of these young men as individuals. These authors recognised that young men, as much as young women, are attempting to understand and negotiate their growth and identity as gendered human beings and simultaneously as professional engineers. They cautioned that collective descriptions could provide a more negative picture than seemed warranted by individual interactions. Student interviews and observations in the wide variety of studies discussed in this section, have demonstrated, however, that for engineering education the collective behaviours described above were real, and were likely to have real effects on others.

### 2.6.4 Masculinity(ies) – not one but many

Historically, engineering has been seen as glorifying its hard masculinity (Lewis et al., 1998). It was increasingly being recognised (Ford & Ford, 1994; Henwood, 1998; McLean et al., 1997; Tonso, 1997) that even within engineering, masculinity was displayed in different ways, and was a socially constructed, dynamic concept. Contemporary theories of masculinity (Connell, 1995; Segal, 1990) used the concept of dominant or hegemonic masculinity as that form which was most highly valued in a particular context. Factors such as class, race, ethnicity, education and sexuality were viewed as likely to cause variation within and between groups of men, but it has been recognised that in Australian (McLean et al., 1997) and New Zealand (Phillips, 1996) society the dominant masculinity was predominantly white, middle-class and heterosexual. Connell (1995) suggested that those men or boys who most closely conformed to the values of the hegemonic masculinity would occupy the dominant positions in relation to subordinate masculine styles. Dominant masculinities were also identified by Tonso (1997) as according greater value to some cultural identities (ways of belonging) than others, where value was manifested as success in terms of academic grades and employment opportunities. She identified that these successful cultural identities were rarely open to women.

The masculinity of the engineering education culture described by these studies was obviously far from monolithic as was evidenced by the contradiction of students attempting to simultaneously live up to an image as fun loving, beer drinking louts, and members of a high status, high workload degree course. There appeared to be an increasing recognition, also, that the historic engineering masculinity was under threat from rapidly increasing ethnic diversity in the staff and student bodies and economic constraints imposed by high tuition fees (Hansen & Godfrey, 1997; Taylor & Yates, 1995).

Ethnic diversity in understandings of masculinity and femininity has not been addressed in any of the cultural studies referred to in this review although Seymour and Hewitt's (1997) study recognised that some students viewed education through markedly different "filters". Lewis in Australia, Stonyer in New Zealand, and Tonso in the USA all acknowledged that consideration of race and ethnicity compounded the variables and issues to be studied, and explicitly chose to work with the dominant (white or Anglo) majority. Rosser (1995) warned that for many students race may be a more significant factor than gender for under-representation in the sciences. Clewell and Ginorio (1996) also sounded a warning that "research on causes of underrepresentation of white women and girls is not generalisable to women and girls of colour. Neither is research conducted on girls and women of one race or social class generalisable to those of other races or social classes" (p.212).

Lewis et al. (1998) proposed that those aspects of engineering culture that were most distasteful to women were in fact motivated by fear of not being male enough, rather than self confident assertions of masculine power, a concept which seemed to be reinforced by Dunlop’s study. In his investigation “Engineering: Constructed in the masculine image?” Dunlop (1991) advanced the idea that the typical engineer was characterised by some strong masculine qualities such as industrious, independent, self controlled, competitive and strong willed but not others such as daring and risk-taking. The strength of Dunlop’s study was that rather than engineers being defined in terms of masculinity, he argued that they were defined in terms of “not-feminine” and it was the predominance of this particular type of male who had imposed a narrow male image on the field.

In this section on gender and the culture of engineering education I have provided an overview of the growth of the discourse and theorising around women’s under-representation in engineering education from issues of access and support to those of inclusivity in the curriculum, the learning environment and more recently the culture itself. In the next section I will summarise the gaps and limitations in current practice and theory that have emerged from the research and literature reviewed in this chapter.

## 2.7 Gaps in the literature – Rationale for the research

My aim in this chapter has been to review the literature pertaining to the culture of engineering education and its interaction with gender on which I have grounded my study. I have reviewed a comprehensive subset of the research literature in this chapter to explore, in greater depth, gaps and unresolved questions within the limitations summarised in Chapter 1 as the rationale for my study. I will now briefly restate the limitations, gaps and unanswered questions which have emerged from this literature review.

### 2.7.1 Limitations of intervention strategies

As I have outlined in Chapter 1, and supported by theorising reviewed in this chapter, a major limitation in the majority of current intervention strategies and the theorising behind them, is that they welcome women into the existing culture. The existing culture has been seen as a major deterrent to women’s increased participation, with the need identified by many authors (Cronin & Roger, 1999) to address the conflict between feminine identity and the masculine culture. I have inferred from this body of opinion that an accessible theoretical and research base is required on which to build strategies to address this conflict and its implicit duality.

### 2.7.2 Lack of definition of concept of culture (at both academic and social levels), in the context of engineering education.

My literature review in section 2.2 has provided a wealth of understandings around the behaviours and practices commonly found within engineering, but a dearth of studies at a cultural level coming from within mainstream engineering. To disrupt the existing culture, I argue, requires an understanding of why behaviours and practices are so hard to shift. I have interpreted the lack of familiarity with cultural concepts within engineering as significant, given that culture theorists (referred to in section 2.3), have proposed that patterns of behaviour and practice are formed and sustained as manifestations of values, beliefs and unconsciously held assumptions. The literature revealed a mismatch between many of the cultural norms found in engineering education and the espoused values promoted by the profession and educational institutions in publications such as the IEAust Review (1996).

The literature has also revealed the lack of a “voice” from within engineering, with much of the previous cultural research building on associated studies in science and science education, and conducted by social scientists bringing a feminist perspective. I argue that this has resulted in the omission from the literature of aspects of the engineering culture which provide it with much of its unique character, such as the role of design, mathematics and the engineering method.

From this literature I have identified the need for an accessible and acceptable framework within which to discuss culture in the context of the engineering profession and education. My hypothesis is that such a framework will inform the discourse around the interaction of gender and other diversities with that culture.

### 2.7.3 Limitations of theorising from previous research on the interaction of gender with the culture of engineering education

My review in section 2.6 has discussed the growing literature on the interaction of gender with the culture of engineering education, and its contribution to what I have perceived as a still incomplete picture.

Perhaps the most limiting factor, in my view, is the strength of the masculine/feminine duality inherent in so much of the research reviewed. Despite the growing influence of gender research which views both masculinity and femininity as socially constructed and open to change and flexibility in different contexts, referral is often made to previous studies which have grouped women and men as homogeneous categories opposed in a binary fashion. Stereotypical assumptions regarding masculinity and femininity are deeply rooted in societal values and beliefs but research which will address the conflict between feminine identity and the masculine values and norms of engineering education identified earlier should, I argue, take note of the range of masculinities and femininities within engineering and the potential for overlap and inclusion. New approaches to language and the use of terms such as gendered and gender-related may allow the fluidity Baxter Magolda (1992) spoke of as “prevailing winds” to be used to identify patterns of behaviour and ways of knowing.

I regarded the ethnocentricity of the most previous studies a limiting factor considering the increasing ethnic and cultural diversity of both Australian and New Zealand engineering classrooms which has resulted in white, middle class males no longer being a majority in many institutions. I found little consideration in the literature of the implications of this ethnic diversity for the culture of engineering education.

In the late 1990s higher education and many engineering institutions have been subject to considerable change, from external sources and internal changes to curricula and structure attempting to meet the challenges and goals recommended internationally. I saw the need to situate the findings of previous research literature in a context that included time and place when considering relevance to proposed strategies. A question which arose for me was, “Have these efforts to change curricula, and teaching practices resulted in shifts in the culture that might have implications for gender?”

As noted earlier, several authors (McLean et al. 1997; Tonso, 1997) have commented that more study is needed on the dynamic, interactional processes that create and sustain the both the gendered identities of participants and the gendered norms of the culture of engineering education. A variety of behaviours and practices have been commented on, but less has been learned about the processes that cause or disrupt their manifestation.

Another major limitation with studies considering the interaction of gender with the culture of engineering education is their location outside mainstream engineering. I wish to forefront the need for strategies that present the concepts of gender inclusivity to a wider audience within engineering education in ways that do not reinforce perceptions of deficiency or disadvantage.

Studies commented on in this literature appear to have skimmed the surface of examining the implications for gender of the unique nature of the ways in which engineering values and displays knowledge, at the levels of teaching learning and assessment. The role of Design and the “Engineering method” recognised by professional engineers as essential features in the training of engineering students have not been addressed in the gender literature. Except for the early work of Hacker (1983) the role and importance of mathematics within engineering, for example, have not been analysed in depth. These were features which I perceived as essential to an understanding of the engineering education culture in which both academic and social integration have been perceived as essential for women.

### 2.7.4 Almost complete lack of theorising on subcultures within the culture of engineering education

The likelihood of subcultures has been recognised (Lewis et al. 1998; Cu WaT, 1998) and in Chapter 1 I have discussed suggestions by Byrne (1993) and Cobbin (1995) of the sources of the long lasting differential participation by women in the engineering sub-discipline. Given that the operating unit for most staff and students in engineering, for at least three years of their academic life, is at the close knit departmental level I posit that the almost complete lack of theorising about the formation of these disciplinary subcultures needs addressing.

Those subcultures (institutional or discipline specific) with a high participation of women that appear to provide an inclusive cultural experience for women students and others of minority groups may provide the basis of appropriate cultural change strategies. It seems likely that they have developed norms, values and beliefs that have "opened" up the culture of engineering education to value and welcome the participation of women. Similarly, an investigation of the features, both academic and social, of those disciplines which remain obdurately low in women's participation may provide revealing information about perceived barriers.

### 2.7.5 Limited research on the processes of enculturation – "Learning the culture"

The first author who stressed the importance of "enculturation into a well-established system of practices, meanings and beliefs" as students "learn what it means to be an engineer" was Tonso (1996b, p.218). As I have discussed in section 2.3 an understanding of the concept of culture leads to a recognition of the importance of the process of learning the culture. The majority of the engineering education literature has used surveys and interviews as the preferred data collection method. These methods are likely to provide evidence of cultural practices and behaviours, but I saw them as unlikely to provide insights into the processes that sustain and maintain those behaviours and practices. Only a few studies have used participant observation (Tonso, 1997) or ethnographic methods (Jolly, 1996) to gain insights into the processes of how the culture is learned, but they have provided a limited picture. I suggest that an important contribution to the literature would be studies which examined the processes by which the curriculum, teaching and learning styles, classroom and laboratory dynamics, assessment procedures and peer relationships enculturate students into "doing engineering" at the same time as they are "doing gender" – learning how to operate successfully as women and men within the educational (and later professional) setting.

## 2.8 Summary

The limitations and unanswered questions that I have identified in this literature review have resulted in my choice of Research Questions. My investigations seeking to answer these questions, are intended to have theoretical and practical significance in informing the research base on which strategies aimed at increasing women's participation in engineering can be developed.

# Chapter 3

## Methodology and Analysis

*What we find as researchers depends on how deeply we cast our nets, how narrow the mesh is and what ponds we choose to fish in.*
*Allison (1974) cited in Trowler, 1998, p.147*

### 3.1 Purpose and outline of Chapter

In this chapter I describe the research design, methodology and subsequent analysis procedures used to answer my research questions. I discuss my interpretive case study approach to the research and my predominantly ethnographic methods of data collection. A "road map" of the procedures used for data collection and analysis is provided, demonstrating how a chain of evidence leads to my findings in later chapters. At all stages of the research, I aimed to ensure the rigour of my analysis and consequent validity of my results, and in this sense issues of ethical considerations and trustworthiness are addressed.

### 3.2 Research design and data collection methods

I chose my research design to align my methodology and analysis with my research questions, the likely nature of my research data and my research goals. As indicated earlier my research questions were:

- What are the dimensions/elements of the culture of engineering education in the case study institution and how do they interact with gender?
- How is the culture of engineering education learned in the case study institution and how does gender interact with this learning process?
- Viewing subdisciplines as cultures within the culture of engineering education in the case study institution, how do they interact with gender?

Also as indicated earlier, I chose to use Schein's theoretical framework and definition of culture (Schein, 1985, 1992) as the starting point for this study. Although Schein's approach has been critiqued as a "functionalist" rather than "interpretive" approach (Hatch, 1993), in common with other culture theorists he has emphasised the need to go below the surface level of observable artefacts and behaviours to more tacitly known cultural knowledge and norms. In Schein's framework the essence of culture exists in the deepest, unconscious level of basic beliefs and assumptions, which underpins the more visible cultural manifestations. To develop an understanding of these beliefs and assumptions, I considered an interpretive approach likely to be most productive. I noted Schein's (1991) view that extensive ethnographic research was required to understand this deepest level of culture, and his suggestion that the process could be shortened with the assistance of motivated "insiders".

Initially, because my early academic background and the likely audience for this study were both anchored in the positivist disciplines of science and engineering, I was drawn towards quantitative methodology (e.g. Hofstede et al., 1990). However, Schein (1991) was very negative about research that attempts to define culture as something measurable through individual questionnaires, which can either force data into dimensions derived *a priori* or use factor analysis. He saw these methods as implying that culture was definable at the surface level and suggested that it was "highly unlikely that pre-determined dimensions that led to questionnaire construction adequately covered the conceptual terrain that culture deals with in human systems" (p.244). Also it seemed unlikely to me that Likert-style questionnaires and their associated statistics could contribute to a better understanding of the cultural dynamics and processes of enculturation, given that the latter, as suggested by McLean et al (1997) and Tonso (1996), appear to be inextricably linked in the interaction of gender with the culture of engineering education.

Discussing cultural studies in higher education, Trowler (1998, p.147) proposed that an insider account based on multiple methods of data collection had the potential to uncover the meanings, understandings and intentions of the members of a culture. He criticised much of higher education research, which he suggested cast its net too near the surface, "the front of stage" discourse rather than what was happening behind the scenes in the day-to-day lives of those involved. Smircich (1983b) suggested that the "researcher needed to be close to, not detached from, social interactions in which meanings were rooted and elaborated" with "data only becoming significant when they were made sensible and coherent through the mediation of human meaning" (p. 164).

Thus, based on the precedents set by these earlier researchers and the need for insider knowledge, I saw an interpretivist research paradigm as the most appropriate for my study. The term "research paradigm" has been suggested to be "the network of coherent ideas about the nature of the world and the functions of researchers which conditions the patterns of their thinking and underpins their research actions" (Bassey, 1999, p.42). Positivist and interpretivist research paradigms were suggested by Bassey to indicate differing beliefs about the nature of reality and in consequence differing underpinnings for research actions. He suggested that positivists expect a single, tangible reality where knower and known are independent, and time and context free generalisations are possible. Things and events in such a reality are measurable and can be counted, and therefore the methodologies used by positivists are quantitative. In contrast the interpretive researcher, Bassey suggested, saw reality as a construct of the human mind resulting in similar, but not necessarily the same, understandings. As a consequence, interpretive enquiry tries to uncover structures of meaning in use in a setting and "synthesise an image of that group's reality and make it available for consideration and reflection" (Smircich, 1983b, p.164).

Research in engineering education has been said to "almost exclusively depend on positivist methods of research using experimental evidence, usually quantitative, to support a defined hypothesis" (Tonso, 1996a, p.143). By contrast, Tonso and others (McLean et al, 1997; Radcliffe, Crosthwaite & Jolly, 2002; Waller, 2001) advocate the use of qualitative research methodologies. As engineers stepping outside their perceived discipline boundaries they recognise that, contrary to the positivist research paradigm where the researcher is assumed to be objective, unbiased and distinct from the participants, a fundamental concept within qualitative research is the need for local knowledge and interpretation in order to assign meaning to words and actions consistent with the meanings assigned by members of the group under study. Subjectivity is seen as inherent within qualitative research, with the researcher the "primary instrument of data collection and analysis" (Merriam, 1988, p. 39).

Within my chosen interpretivist research paradigm, I saw qualitative methodologies as having the following characteristics (drawing on Bogdan & Biklen, 1982; Lincoln & Guba, 1985; Merriam, 1988):

- The primary concern is often with process rather than outcomes or products;
- The aim is to interpret manifest behaviour and search for meaning, assuming that meaning is embedded in people's experiences;
- All data collection is mediated, responded to, and analysed through the human instrument – the researcher;
- Words or pictures are both the elements of data and the means of conveying what has been learned about the phenomenon;
- Inductive approaches to data analysis are used to build abstractions, concepts, hypotheses or theories rather than test existing theory;
- Data collection and analysis are rarely linear or straightforward but more commonly iterative and responsive.

One goal for my study was that it should be accessible and acceptable by engineering educators, for whom the interpretivist research paradigm was non-traditional. If this paradigm was used it was important that my study was seen by my peers as valid and "scientific". I will discuss in section 3.3.7 the ways in which I endeavoured to ensure that my study can be evaluated on the basis of the integrity and soundness of the analysis.

### 3.2.1 Why a case study and what type of case study?

In my research design I chose to study one institution in depth, over a specified period of time. This fits Stake's (1994) definition of a case study as requiring specificity, uniqueness and the ability to bound the system under study. Although definitions of the exact nature of a case study abounded in the literature, there appeared to be agreement that case study research always involves "the study of an instance in action" (Bassey, 1999, p. 24) which allowed the researcher to "reveal the multiplicity of factors which have interacted to produce the unique character of the entity that is the subject of study" (Yin, 1988 p.82 cited by Haigh, 2000).

Using a case study for the purpose of building theory has been recognised by several authors (Bassey, 1999; Merriam, 1988; Stake 1994) as a common, and valid research design, particularly in education. In such cases, the case itself is said to be of secondary interest, "playing a supportive role as it facilitates our understanding of something else" (Stake, 1994, p. 237) in this instance, defining the dimensions of the culture of engineering education.

One criticism that has been levelled against the use of case studies is that working with one system, in this case one institution, makes the findings too specific and theory therefore not suitable for generalisation. Yin (1994, p.10) countered this criticism with the reminder that the goal of a singular case study was to generate or test theory ("analytic generalisation") rather than enumerate frequencies ("statistical generalisation") and that the conclusions found were generalisable to theoretical propositions rather than populations and universes.

My reading also identified that case studies often draw upon a range of disciplines for theoretical orientation and techniques of data analysis and collection, and although the majority use naturalistic inquiry or qualitative research methods, these methods are not a prerequisite. Indeed it is a feature of case studies that they use a multiplicity of data collection methods and analyses.

Although not linked specifically to a particular discipline, my research design followed the lead of a large number of earlier culture researchers from anthropology, sociology and organisational studies (Schein, 1985; Spradley, 1979; Tonso, 1997) in using ethnographic methods such as participant observation within the overarching interpretivist research paradigm. Denzin (1989) suggested that a central feature of an ethnographic approach was that data are collected by a participant observer who is committed to adopting the perspectives of those studied by sharing in their day-to-day experiences. Although my study was not designed entirely as an ethnography, my role as participant observer was "doing ethnography" which was the description, classification and interpretation of a particular group's way of life. I saw this approach as appropriate for answering my research questions, directed as they were at accessing cultural beliefs and assumptions. In particular I suggest that these methods were well suited within a cultural study which needed to answer questions like “what is going on here?” and to decipher “how things are” and “how they got to be that way”.

Merriam (1988, p.27) proposed that a desired outcome of “building theory or conceptualisation of categories”, from the gathering of “rich, thick descriptive data” and subsequent interpretation, characterised a study as an interpretive case study in which the usual mode of analysis was inductive.

In summary, therefore, I have designed my study as an interpretive (theory building) case study including, although not exclusively, ethnographic methods within an overarching interpretivist research paradigm. My analysis of previous research convinced me that this research design would allow me to analyse in depth the culture of the case institution, and using Schein’s theoretical framework as a starting point, provide answers to my research questions.

## 3.3 Main Study Procedure

Eisenhardt (2002) proposed a “road map” for theory building case studies. Although I primarily used the work of earlier authors such as Merriam (1988), Yin (1994), and Strauss & Corbin (1990) to guide my research design and data collection, combined with the work of Miles & Huberman (1994) and Bogdan & Biklen (1982) to guide data analysis, the ‘road map’ suggested by Eisenhardt provides a useful framework within which to discuss my study procedure. This road map is summarised and adapted with reference to this study in the Table 3.1.

Table 3.1 "Road map" of my Research design (adapted from Eisenhardt, 2002)

| *Step* | *Activity* | *Thesis reference* |
|---|---|---|
| Getting started | Initial definition of research questions<br>Some initial albeit tentative theoretical constructs | 3.3.1 |
| Selecting a case | Selection of an appropriate site-chosen for theoretical not statistical reasons | 3.3.2 |
| Crafting Instruments | Multiple data collection methods – potential triangulation of evidence<br>Including qualitative and quantitative | 3.3.3 |
| Entering the Field | Frequent overlap of data collection and analysis including field notes<br>Flexible and opportunistic data collection methods | 3.3.4 |
| Analysing Data | Within-case analysis, gaining familiarity with data<br>Emergent themes and categories | 3.3.5 |
| Shaping Theory/ Categories | Tentative themes, concepts and relationships emerge<br>Highly iterative – aim for theory to closely fit data | 3.4<br>Chapter 4,5,6 and 7 |
| Enfolding Literature | Comparison of emergent theory with existing literature | Chapter 7, and 9 |
| Reaching Closure | Incremental improvement to theory is minimal<br>Theory proposed and implications for further study | Chapter 9 |

In the rest of this chapter I have outlined the first six steps on this "road map", up to the point where the results of data collection and coding have identified the first level of culture, the observable, and tangible cultural manifestations.

### 3.3.1 Background

Almost simultaneously with my decision to pursue doctoral study the *National Position Paper for Women in Engineering* (Roberts & Lewis, 1996) and the IEAust Review of Engineering Education *Changing the Culture* (IEAust, 1996) were released. At a personal level, these documents and their focus on culture had been preceded by my participation in discussions at the first Australasian Women in Engineering Forum in 1994 entitled *Transforming cultures: Nurturing diversity in* *organisations*. These documents and discussions focussed my research topic on exploring the nature of the engineering education culture and its interaction with gender. By the end of 1997, I had identified a lack of theorising around engineering education as a disciplinary culture (discussed previously in chapter 2), which led me to the realisation that using an interpretive case study to build substantive theory would contribute to a better understanding of the role of culture in the participation of women. It is widely recognised (Merriam, 1988; Eisenhardt, 2002) that case studies undertaken to build theory use an inductive rather than deductive mode of thinking. My practical experience and familiarity with previous research in the field are not uncommon in this type of research, where the researcher acknowledges a prior interest in a particular phenomenon, and the possibility of prior knowledge, assumptions or theories. Using ethnographic methods with a sensitive and discriminating ‘eye’ for contradictory as well as confirming evidence of patterns or conceptual categories has been seen (Strauss & Corbin, 1990) as allowing a researcher, such as myself, to proceed beyond that base of prior knowledge to new insights and theory development.

My extensive knowledge of the women in engineering literature and Schein’s theoretical framework (1985) for culture analysis together filled the role of Eisenhardt’s (2002) “a priori specification of theoretical constructs” in my study. Schein’s framework, in particular, gave direction, and enabled my thinking to move from the purely phenomenal to the culturally significant.

### 3.3.2 Choice of site for case study

I saw the key issue in choosing a site for a case study as lying in “what it is you want to be able to say something about at the end of the study” (Patton, 1980, p.100 cited by Merriam 1988, p.44). My research goal of establishing whether there was a causal link between the dimensions of the culture and the under-representation of women led me suggest that the School of Engineering at the U of A would be a desirable institution to use as my case for the study for the following three reasons: the availability of access and the opportunity for prolonged engagement; a relatively high female participation rate of over 18%; and, the introduction of a new degree structure and curriculum in 1996, the year immediately prior to my study.

To expand on the significance of these reasons:

1. *The availability of access and the opportunity for prolonged engagement.*

As noted in earlier chapters, I came to this investigation with seven years of close contact with the case study institution, its staff and students, and the global community of advocates for women in science and engineering. My unique position as an accepted member of the School of Engineering, with a position on committees such as the Teaching Committee, and the Schools' Liaison Committee and as Chair of the Equal Opportunities Committee, carried with it a high level of trust and respect particularly in relation to the School's efforts to increase female participation.

> *…it seems to me you have been effective because you have empathy both for the male students and for the women students. You have been supportive of the School of Engineering and increasingly became very comfortable in this environment…*
>
> *exDean1, 4/10/97*

Because my funding and reporting lines came from the university's central administration my position has been depicted (Stonyer, 1996) as outside the systems of power and authority within the School and therefore marginalised. In the sense of lacking power to personally manifest change, I agreed with Stonyer's critique. However, I perceived this "marginalisation" as having the advantage that I could critique structures and systems, express disagreement and often influence change without fear of personal redress or repercussions. Recognising my unique position, both staff and students appeared to be comfortable during this research discussing a range of academic and personal issues with me. Several cultural theorists (Schein, 1985; Smircich, 1983b; Trowler, 1998) had suggested that to interpret the manifestations of culture and illuminate the beliefs, values and norms that lie at the core of a culture required a combination of closeness and distance. I believe that I have had that mixture, which, combined with the trust of the members of the culture, was a major strength in the credibility of this research.

2. *In 1996 at the beginning of this study the female participation rate was over 18% and still rising.*

This percentage was higher than the majority of multidisciplinary engineering schools in New Zealand or Australia. I concluded that the culture of engineering education as evidenced in this institution might therefore have features that were encouraging the participation of female students.

3. *Changes to the degree structure and composition of the student body led me to suggest that a study of the culture at this institution was timely.*

The new degree structure and curriculum, implemented in 1996 (to be described in Chapter 4), appeared to have included many of the changes later recommended in the 1996 Australian Review of Engineering Education. I considered that an analysis of the culture of engineering education in the case study institution and its interaction with gender would demonstrate whether these changes, as predicted by the Australian review, had resulted in an inclusive culture.

I recognised the possibility that using my home institution as the case study, had the potential for my close association to have influenced the culture of the institution, particularly as it may have impacted on the level of female participation or the development of an inclusive culture. The nature and extent, if any, of that influence will be revealed in the cultural analysis.

### 3.3.3 Selection of data sources

Case studies using ethnographic methods are typically built up from multiple sources of evidence, known as triangulation, "the development of converging lines of inquiry" (Yin, 1994, p.92). Triangulation has been seen to take several forms, all of which enhance reliability and validity of data interpretation. Methodological triangulation, common in qualitative research, combines dissimilar methods such as interviews, observations, and physical evidence to study the same unit. Within the interpretivist research paradigm the majority of data will be qualitative i.e. words, but quantitative data are also appropriate within the same study (Eisenhardt, 2002) particularly in support of a generalisation made from a single or limited observation. It has been suggested (Denzin, 1970 cited in Merriam 1988, p.69) that "the rationale for this strategy (methodological triangulation) is that the flaws of one method are often the strengths of another and by combining methods observers can achieve the best of each". Data triangulation uses purposive sampling within one method, such as interviews, to ensure different perspectives by choosing participants of different gender, status, ethnicity, and, where deemed useful, participants known to hold opposing or alternate viewpoints. A comparison of data from different years and different students and staff, made possible by long term and repeated observation is another way of validating the interpretation of data, and this has been named as time triangulation (Cohen & Manion, 1994).

In the next section, 3.3.4, I have detailed my data collection methods which included participant observation, interviews, questionnaires, focus groups and workshops, statistics, plus a wide range of documents and publications. The sources of data outlined in the next section evidence the use of methodological, data and time triangulation – all contributing to the credibility of my theory development.

### 3.3.4 Data Collection

Data collection was not conducted in a fixed time progression. I have discussed how the collection and preliminary analysis of some data stimulated the further collection and use of other data collecting strategies. Data were stored and filed systematically, in both electronic and hard copy formats as appropriate, adhering to "best practice" models (Miles & Huberman, 1994) that would permit an audit trail of data collection and analysis.

The time frame for data collection was the years 1996 to 1999 inclusive, although participant observation and feedback from graduates and staff continued through iterative feedback processes until the submission of my study. Student data collection was unable to be continued post-1999 due to my change in employment to a position of authority within the School of Engineering, a change which I believed had the potential to compromise the validity of student responses.

#### *3.3.4.1 Questionnaire/Survey*

I recognised that it was unlikely to be possible, within the bounds of this study, to interview a full range of students that would include all the possible variables (namely six separate engineering degrees, four 'year' levels, male and female, and a very wide range of ethnic groups). A questionnaire would, I felt, provide the opportunity to survey a larger group and gauge the range and degree of agreement in students' views of their engineering education.

I determined the goals of a questionnaire distributed to final year students to be:

- To get "broad brush" information on individual students' experiences, both academic and social of their engineering education;
- To provide a basic set of themes and issues to be explored in greater depth by further interviews;
- To look for commonalities and shared understandings, but also contradictions and differences that might be linked to gender, ethnicity or engineering disciplines;
- To give voice to those who might otherwise be 'silent' when interviews were conducted with a much smaller group. I particularly wished to solicit responses across the full range of ethnicity and gender;
- To seek impartial, anonymous responses which would not be affected by bias that might otherwise occur in an interview situation where I was likely to be known to many of the informants.

<u>Final Year students 1997</u>

With these aims in mind I posted an open-ended questionnaire to all female students (50) finishing their degree at the end of 1997 and 100 male students matched to the female students by discipline and ethnicity but chosen randomly within those criteria. The accompanying letter stated the nature of my research, made it clear that the questionnaire was to be completed anonymously and that my research had the permission and approval of the Dean of the School of Engineering. Several male and female students signed their names on their response forms and volunteered to provide further in-depth information.

The questions focussed on the students' perceptions of their experiences both academically and socially. Prior to mailing, I trialled the questionnaire with several students for whom English was not a first language and altered terminology where necessary. I was particularly interested to identify any gender differences in the responses. My experience and discussions with students over a number of years had suggested that some students had preconceptions about the strengths and abilities of other students based on gender. I therefore prepared two versions of the questionnaire, one for female recipients and one for males. (Ref. Appendix 3). The first two pages were the same but the third page began "As a male (female) student in the School of Engineering your experiences may differ from those of your colleagues. I would appreciate comments from your own experience….”

I mailed out the questionnaire during the period of final year examinations to ensure firstly, that term addresses would be current, and, secondly, because my experience suggested that students ready to graduate were likely to have a reflective view of their studies and their progress through the degree and might be happy to use the questionnaire to feedback their experiences.

Twenty eight females (56%), and 27 males (27%) responded. Although the focus of the research was stated to be on engineering education and most questions were not gender specific, my role with the School and a generally defensive attitude around gender issues may have resulted in male students feeling less involved and therefore less willing to respond. Although I was disappointed with the male response rate it was in the range quoted as normal (Alreck & Settle, 1995) for a postal questionnaire without follow up reminders, and provided an acceptable cross section of responses. Table 3.2 provides a summary of the response categories.

Table 3.2 Summary of Responses to 1997 Mailed Questionnaire

| **Sex** | **Discipline** | | **Ethnicity** | |
|---|---|---|---|---|
| Female | Chem. & Materials | 11 | NZ European | 22 |
| | Civil | 9 | Asian | 5 |
| | Elect & Electronic | 4 | Arabic | 1 |
| | Engineering Science | 1 | | |
| | Mechanical | 3 | | |
| | | | | |
| Male | Chem & Materials | 8 | NZ European | 15 |
| | Civil | 10 | Maori or Polynesian | 3 |
| | Elect & Electronic | 6 | Asian | 9 |
| | Engineering Science | 1 | | |
| | Mechanical | 1 | | |
| | Unstated | 1 | | |

The proportion of students of Asian descent who returned questionnaires is undoubtedly lower than their proportional representation in the School of Engineering final year class. I attributed possible factors responsible for this lower response rate as: a reluctance and discomfort in critiquing their education, lack of trust in the anonymity of the process, or lack of confidence in the use of language. I hoped to gain further feedback from this group in the interview process. My questionnaire sought information on

- Why students chose engineering and whether they had been happy with that decision;
- Student experiences within the academic environment – their coursework, teaching etc.;
- Student experiences of the social environment in which learning takes place;
- Student perceptions of the possibility of gender differences in their education experience and abilities.

I asked for the student's personal experiences of the lecturers, their fellow students, and the course work and framed the questions in encouraging and open ended ways such as: "Were there any courses that you particularly enjoyed and why do you think that was?" and similarly "Were there any courses that you did not enjoy and why do you think that was?" I thus hoped to highlight practices and behaviours which could be further discussed and clarified in the interview process to illuminate the cultural values, beliefs and attitudes held by the students.

My analysis of this survey was that, for the students who had made it through to their final year and were about to graduate, there were many shared understandings and values of what "doing engineering" meant. I acknowledged these students as the "survivors", who had become "enculturated" in the culture of engineering education as evidenced in the case study institution. It was a feature of the questionnaire responses that they showed little if any variation by gender.

<u>Staff Questionnaire – September 1997</u>

Early in my data collection, my observations and the discussion with students led me to believe that academic staff held a wide range of beliefs and assumptions around gender, some of which might be considered as “politically incorrect” in an institution which publicly espoused the value of equal educational opportunity and forbade discrimination on the basis of gender or race. To surface these opinions in a non-threatening manner, prior to conducting in-depth staff interviews, I circulated a brief questionnaire (Ref Appendix 4) to all academic staff. The questionnaire enabled them to, anonymously, provide me with information on their perceptions of gendered differences in behaviour, learning styles, abilities, and confidence. It also asked for their thoughts on the low female participation in engineering education.

The questionnaire was open ended, asking for personal opinions and perceptions. The accompanying letter reminded the respondents of current statistics. It described the nature of my personal research and the fact that this had been given the approval of the Dean and the Faculty in 1996. I piloted the questionnaire on a colleague with qualitative research expertise, and a female and a male engineering staff member, to ensure that terminology and the questions asked were unbiased, non-threatening and encouraging of open responses. Minor changes were suggested, which I made. I used a format that ensured anonymity and assured staff of the confidentiality of their responses, although I made an option available for any staff member who wished to discuss the matter further to self identify. A number of staff members chose a short interview to elaborate on their answers. The response was 28% overall, although only 8% (2/25) responses were received from the department of Electrical and Electronic Engineering. It was suggested by a participant that this low response rate may have been typical for academic staff questionnaires, and that my request for information regarding positioning within an age range, and length of time within the institution may have been seen as compromising anonymity by some individuals. The responses however, were revealing, particularly in their indications of the level of understanding related to gender issues. A defensive tone was evident in some responses, and several staff, who did not respond, commented to me that they found the issues “too hard”.

<u>Other Questionnaires and Survey Data</u>

To obtain further documentary evidence, I was given access to teaching evaluations performed as quality reviews, and to a variety of student surveys, including the major review of the new Part I programme in 1996 and 1997 (conducted by the University professional development unit). These surveys, prepared by professional academic evaluators, utilised both Likert style questionnaires and open-ended questions, and provided useful data for comparison with my own observations and data collected from interviews.

#### *3.3.4.2 Interviews*

Interviews have been one of the most popular data collecting methods in theory-building case study research, and their strength has been seen to lie in the ability of an interview to target, and focus directly on the case study topic, providing data which is “rich, detailed and insightful” (Yin, 1994). In seeking to uncover the levels of culture, I perceived interviews from knowledgeable, co-operative respondents as likely to provide opportunities to clarify and expand on issues that had arisen from comments in questionnaires, and my own observations. My research placed an emphasis on the evidence gathered from interviews with staff and students of the understandings and tacit knowledge that make up their “lived” experience” within the culture of engineering education. This evidence has been viewed as essential to the interpretation of the beliefs and assumptions which underpin the culture (Sackmann, 1992; Smircich, 1983b).

Random sampling, so intrinsic to positivist methodologies and the discipline of engineering, is not the method of choice in most qualitative case studies. When the questions to be answered are not ‘how much’ or ‘how often’ but discovering, understanding and gaining insights into what occurs in a setting, then it has been recognised that it is necessary to choose respondents from whom one can learn the most (Patton, 1980 cited in Merriam, 1988, p.48). I identified initial informants across a range of status, gender, ethnicity and experience within the setting. This type of sampling has been described as purposive or purposeful sampling (Merriam, 1988). In accord with the practices of inductive analysis and naturalistic inquiry my data collection and analysis and evolving theory development provided me with emerging insights about what was relevant to my study. I also sought further interviews following what Strauss and Corbin (1990) called a “theoretical sampling” procedure to gain both confirming and potentially contradictory data.

The concept of culture was not one with which engineering staff and students, who had very little if any exposure to the social sciences, were familiar, and, as other authors have commented (Taylor, 1998; Solomon, 1996), engineers are not commonly reflective about their practice and the philosophical bases of those practices. My interview transcripts demonstrated that a high proportion of the staff and students recognised that the interview process was the first time they had reflected on some of the issues raised and in many of these cases their observations were at the surface level of describing behaviours and practices. Several respondents had a more insightful view, however, and were able to reflect and articulate "the way we do things round here", often continuing discussions past the first interview, which resulted in them becoming "key informants" (Yin, 1994, p.84).

My interview format was "semi-structured". Certain information was desired from all the respondents. I provided a list of issues to be explored prior to the interview. The interviews were then guided by a schedule of questions around these issues, but I did not adhere rigidly to either the exact wording or order of questions. Merriam (1988) suggested that a semi-structured format allows the researcher to respond to new information or seek further depth where appropriate. I used open-ended questions, looking for both facts and opinions and, where possible, insight into causes and outcomes of practices. My schedule of questions followed recommended "best" practices for interview procedures (Merriam, 1988: Yin, 1994) and was particularly sensitive to issues such as:

(a) starting interviews with "ice breaker" questions such as "Tell me about how you came to choose engineering?" to relax both interviewer and interviewee;
(b) ensuring a common, straightforward vocabulary so that questions were understood;
(c) avoiding the use of multiple questions within one question and, where possible, avoiding questions which would solicit a yes/no answer; and,
(d) ensuring questions were not biased or implied an expected answer.

I conducted interviews with newly graduated students, academic staff and students completing their first year.

Recent graduate interviews

In the early stages of this study, over the summer of 1996-97, I interviewed 17 women students, who had just completed their final year of study, from a variety of engineering disciplines. My goal was to gain insights into their experiences as women students in both the academic and social environments of the case study institution. I used my prior experience in the institution to guide purposive sampling to select respondents whom I knew to be varied in their educational and personal backgrounds. Some of the variation included academic ability, social interaction (or lack of it) within the School of Engineering, participation (or lack of it) in Women in Engineering activities, English as a first language, length of residence in New Zealand, ethnicity and prior educational experience. I chose a larger number of students from Electrical and Electronic Engineering because the experiences of these students appeared to be so different from those in other disciplines. I have shown the distribution of discipline and ethnicity of this group in Table 3.3.

Table 3.3 Summary by discipline, ethnicity and educational background of female final year students interviewed 1996/97.

| **Discipline** | | **Ethnicity** | | **Educational Background** | |
|---|---|---|---|---|---|
| Electrical & Electronic | 8 | NZ European | 10 | From school | 13 |
| Engineering Science | 2 | Middle East | 1 | Army technician | 1 |
| Mechanical | 3 | Indian | 1 | From BSc | 1 |
| Chemical & Materials | 2 | NZ born Chinese | 2 | From BA | 1 |
| Civil Engineering | 2 | Taiwanese | 2 | From employment | |
| | | Malaysian Chinese | 1 | | |

I invited the students to participate in the interviews, either verbally or by a letter that outlined the purpose of my research and the format of the interview together with an outline of the topics we were likely to cover. In a confirming letter I thanked them for their offer of assistance, and provided them with a copy of the proposed interview schedule and how ethical considerations such as anonymity and confidentiality would be met. I obtained their signed consent for the interview and the use of data from the transcript for the purposes of my research. I also gave them the opportunity to choose their own pseudonym and to indicate whether they would like to receive a copy of their transcript. I adopted this procedure with all other interviewees. I conducted the interviews in a place of their choosing, usually their private home, my home or in a private room at the university. At the time of interview, I reminded the participants of the purpose of the study, and again assured them of anonymity and confidentiality. With their permission I audiotaped the interview. The interviews followed a conversational style with the questions being used as a guideline. They varied in length from 45 minutes to 2 hours.

As completing students, I was aware that these young women were all “survivors”, likely to be enculturated into the values and cultural norms which enabled them to complete their degrees and identify as “engineers”. I couched the initial part of their interviews around questions which encouraged them to talk about why they entered engineering and to describe their progress through the degree (Ref Appendix 5). In response to questions such as “Tell me about your first year here, what do you remember?” they encased their experiences of behaviours and practices in a narrative form. When the narrative slowed, my knowledge of the institution enabled me to prompt with questions like “Tell me about your final year project, how did you find that?” I followed up issues around relationships, language, humour and workload as the opportunities presented themselves. Finally I explored with them their perception of whether being a woman had provided them with different experiences to those of their male colleagues. In these initial interviews, I did not mention culture specifically, but recurring themes emerged which I later identified as cultural norms.

Following these initial interviews, with their depth of rich detail, and my emergent focus on culture, all later interviews were more explicitly related to seeking culturally significant data.

At the end of 1997 and early 1998, following the questionnaire mentioned in 3.3.4.1, I interviewed five male final year students. Four of these young men were NZ European, and one was a Pacific Islander. Three were from the Electrical and Electronic department, one was from Civil and the other from Engineering Science. I carried out the same interview protocols with these students except that the issues around which the interviews focussed were (Ref Appendix 6):

- What influenced your choice of engineering as a degree?
- What characterises engineering and engineers?
- What is thinking as an engineer? How are you taught that?
- What 3 or 4 factors really stand out when you think of your time at the School of Engineering?
- What stands out in your memory of your first few weeks?
- Do you think male and female students might have different experiences and abilities with respect to their engineering studies?

Throughout these interviews and those with academic staff it was evident to me that, in common with other studies (Sackmann, 1992), it was difficult to ask members directly about culture and it was more productive to solicit context-specific knowledge around events, behaviours, and practices.

Coincident with the first drafts of my initial findings being prepared for presentation as conference papers in 1998, several recent graduates volunteered to be interviewed. I viewed their contribution as useful in providing information on how a history of common traditions and understandings had become stable with a student population that moved on every four years. Of this group I interviewed two male (both Civil engineers) and five female (2 Engineering Science, 2 Electrical, 1 Civil and 1 Chemical) recent graduates.

The temptation for me to keep interviewing was strong, in recognition of the infinite variety of possible backgrounds, personalities and standpoints. My original intention was to interview the same number of male as female graduating students but, as time progressed, the concurrent processes of data analysis revealed the recurrence of common themes, which were reinforced by questionnaires and participant observation, with very little new information forthcoming. In accordance with Lincoln and Guba's (1985, p.350) suggestion that "saturation of categories" and "emergence of regularities" were theoretical guidelines for ceasing the collection of one type of data, I shifted my focus to data collection for the next phase of my research.

One of my preliminary findings from these interviews and questionnaires was the strength of enculturation, which appeared to cut across both gender and ethnicity. This preliminary finding fed into my exploration of my second research question concerning the processes of enculturation. Data for this question needed to include the perspectives of those who role-modelled and "taught" appropriate cultural practices and those new to the culture who were learning appropriate ways to act and react.

Staff Interviews

The long term stability of academic staff relative to the more rapid student turnover, combined with my perception that academic staff had the influence and power to convert discipline specific values and attitudes to behaviours and practices, made it essential for me to use staff as key informants.

Over the summer of 1997-98, I interviewed two Heads of Department, four senior staff and five junior staff, three of whom were female. My "insider" knowledge enabled me to choose staff known to have a range of perspectives and experience. I selected some staff on the basis of their knowledge and history within the institution, and their contribution to setting policy on academic or social aspects. I sought other staff to provide a diversity of age and experience, including some who were new to New Zealand. Issues of anonymity and confidentiality were especially necessary with this group, and it was a measure of their trust that all were very co-operative and forthcoming. As with my other interviews, I provided an outline of the questions to be asked (Ref Appendix 7) prior to the interview, and I gave staff the option of requesting the tape to be turned off if they wished to discuss any issues "off the record".

An important feature of culture that Schein (1985) identified is whether espoused values, particularly those of the leaders, are observably and tangibly manifested in the culture. For this reason I found it useful to interview one current and one former Dean of the School. Between 1998 and 2002 as data analysis and theory development evolved, a further 12 staff provided feedback and further data via transcribed interviews, with numerous others engaging in informal discussions, making a total of 25 formal interviews with academic staff.

First year student focus groups and interviews

With the specific intent of seeking more information with which to answer my second research question, I conducted focus group interviews and individual interviews with nine female and nine male first year students, in the week before their final examinations in October 1998. This group was chosen by identifying a few initial informants, and asking them to select one other person, with additional students specifically sought to reflect the diversity of the first year class.

Table 3.4 Distribution by gender and ethnicity of first year students interviewed October 1998.

| **Gender** | **Ethnicity** | |
|---|---|---|
| 9 Male | NZ European | 5 |
| | East European | 2 |
| | Malaysian Chinese | 1 |
| | Hong Kong Chinese | 1 |
| 9 Female | NZ European | 5 |
| | Indian (NZ born) | 2 |
| | Chinese (NZ born) | 1 |
| | Indonesian | 1 |

My concern with this group was to identify what they had learned and how they perceived they were being taught, not only about the “way we do things round here” but what it meant to be an engineer. Whereas the new graduates had completed their degree prior to the implementation of the new curriculum in 1996, I hoped these first year students would provide evidence of the effectiveness of the goals and values of the new curriculum (which I describe in Chapter 5).

The same broad issues as outlined for the male graduates formed the basis of the interviews (Ref Appendix 8), with some time spent on what they had identified as ‘the engineering way of doing and thinking”. I used additional questions to provide information on the transition from school to university, group dynamics in project work, the level of competition/cooperation, and the formation of friendships and student-student interactions.

I provided all participants with feedback via e-mail, in the form of common themes and issues which I had identified regarding their experiences and understandings of their first year of study. Approximately half the students responded by elaborating on or clarifying the points raised and in some cases individually contradicting what they acknowledged might be a majority view.

I maintained contact with these students by e-mail, and personal contact through into their second year (98-99) when they had moved into their sub discipline. The students appeared to see me as a person who had a very real interest in what was happening within the process of their education and, as well as formal contact with them in their second year, approximately half the students continued to approach me over later years to speak of happenings and events which might be of interest to my research.

Limitations and Issues with Interviews

A major strength of interviewing is the opportunity to probe for clarification and ask questions appropriate to the respondent's knowledge, involvement and status (Merriam, 1988, p.86). However, like any other method, it is seen as having limitations.

In my study, the relationship between myself and my interviewees was critical to the nature of the data I gained. The goodwill and trust with which students appeared to view me was evidenced in the depth of personal exposure many of them provided in their interviews. I would be the first to acknowledge, however, that response to factors such as my age, sex and role within the institution may have provided me with different data to that collected by another researcher. This is inherent in the subjective nature of this mode of data collection. A male academic staff member commented that "male students will show you their sensitive caring side", and certainly no male students displayed in the interview situation the boisterous, and sometimes crass, behaviours and attitudes I observed from time to time in classrooms and social activities. Because of my long exposure to the site, I regarded myself as able to use discrimination and insight in interpreting the comments from both male and female students. Undercurrents of “wishing to please” or “desiring to impress” did appear to be evident from time to time, and it was not uncommon for students to use phrases like “well, if I am really honest with you…” particularly when speaking on controversial topics such as cheating, or racial issues. Despite taking care with the type of question, and establishing a relationship of trust with my respondents, I was conscious of the possibility of distortion and exaggeration. Merriam (p.85) and Trowler (1998, p.147) both commented that informants are consciously or unconsciously selective in their choice of words, providing an individual perspective rather than facts. Through triangulation I was able to validate interview data by comparison with accounts from other informants, participant observation and other sources of data. Statements such as “our class was such a close group” could be checked against the accounts of other classmates and my own observations. For example, the comment “my class only had three girls” threw an instant spotlight for me on a biased perspective (the class had 20 female students of whom only 3 were of NZ European ethnicity). I was also aware, warned by the ethnographic literature, that my own non-verbal signals such as body language might be interpreted as encouraging or discouraging students and even staff to continue a particular line of thought.

One limitation of my data collection that I regretted was the lack of contributions by male students of an Asian, particularly Chinese, background. The relatively large numbers of these students had the potential, I suspected, to influence the culture at the student level. To some extent their “voices” were heard via the questionnaires, from the Asian female students interviewed and by my own observations. With my focus on the discipline culture and my emerging theory demonstrating that these students were not providing the dominant cultural influences, I made a conscious decision not to pursue further data collection with this group at this time.

#### *3.3.4.3 Participant observation*

Participant observation has been described (Merriam, 1988, p. 89) as the technique of choice in an interpretive case study when behaviour can be observed first hand and where access is possible over extended periods of time. In this case I was working as what Atkinson and Hammersley (1994) and Merriam (1988) described as a “participant as observer”, where my research activities were known to the group but subordinate to my established role within the institution. In my observer role, I watched for the cultural contexts of behaviours and practices, looking for those mutually understood sets of expectations and explanations that enabled me to interpret what was occurring and what meanings were probably being attributed to events by those present.

As well as the many and varied student-staff and staff-staff interactions that were observed in my role of staff member/participant, I sought opportunities, with the permission of the staff (lectures/tutorials) and students (tutorials/workshops) to observe lectures, tutorials, and design workshops, predominantly at Part I and Part II levels in which the new curriculum was being implemented. I reminded staff of the purposes of my research and the nature and purpose of my observations, and did not experience difficulty in gaining access. In classroom situations I played the role of observer only, and did not participate in a teaching role, which quickly resulted in students ignoring my presence. At Part III and Part IV levels, my observations were predominantly in the larger Professional Development courses, project presentations, and design workshops.

For a full week in May 1997 and again in May 1998 I observed the classes and workshops discussed above, to follow up on themes that I had identified during initial interviews and the questionnaires. I observed further classes intermittently until the end of 1999, targeting situations or issues that had arisen during the cycle of data collection and analysis. In classroom/tutorial observations I took field notes that were later expanded around headings such as:

- Size of class and patterns of seating. Who sat where and with whom?;
- Lecturing style – including quality and quantity of interactions with students, and use of technology;
- Did lecture content include real life applications?;
- Who asked questions, what type of questions and responses?;
- Language style – and use of humour;
- Student – student interactions before, during and after lectures including

comments of both private and public intent;

- Behaviour patterns.

In tutorials or design workshops I was especially concerned with observing the dynamics and nature of between- and across- gender and ethnicity student-student interactions.

I kept a field-notes diary from late 1996 to the end of 1999, in which I recorded same-day observations from formal and informal meetings, conversations and interactions with both staff and students. Clearly, I did not record every conversation or happening, but my discrimination grew, alongside the growth in my understanding, in terms of which behaviours and practices were potentially culturally significant.

Over the period of the study I became increasingly aware of the importance of Merriam's suggestion that participant observation involves a balance or tradeoff between the depth of information that is revealed and the level of trust and confidence in the promised confidentiality. In recognition of this need for trust, and with awareness of my ongoing commitment to working in the institution, I took care to distinguish my employed role and role as a researcher in conversations which appeared to be of interest for my study. I sought permission wherever possible to use a quote given in such informal situations.

#### *3.3.4.4 Documentary evidence*

Documents are another source of evidence, including a broad range of written records, available materials and data that Merriam (1988, p. 104) described as a "ready-made source of data easily accessible to the imaginative and resourceful investigator". To ensure that the volume of documentation did not become excessive I used my research questions as a guide at all times. I asked myself: What information or insight into cultural behaviours and practices does this documentation provide? How do these data support the perceptions and memories of staff and students? I was able to check statements such as "half my class was female" against statistical data – often with surprising results. Similarly, emerging themes during my interviews and observations in the field guided my sourcing of documentary evidence to confirm or contradict. I was advantaged in this research by the co-operation and ease of access provided by the institution to current and historical documentation.

I kept an inventory of all documents selected as potential sources of data for my study. A summary of this inventory is presented in Appendix 9.

In my study, the strengths and advantages of using documentary evidence as data could be summarised as:

- They were exact – precise and quantitative, containing exact names, references and details of an event;
- They provided broad coverage;
- They were unchanging and could be reviewed repeatedly.

The context and purpose of the documentation were important, and reporting biases were a potential limitation if insider knowledge was not available. Examples were the positive "best picture" bias likely in recruitment literature and documents prepared for an Accreditation Review, and meeting minutes that provided only the final decision, rarely containing details of contentious discussion or even that discussion had occurred.

#### *3.3.4.5 Artefacts*

Material artefacts, which provide insight into values and norms around social interactions, the physical environment and usage of technology, were suggested by Erlandson, Harris, Skipper and Allen (1993) as an important component to understanding cultural significances. I gathered evidence of the cultural significance of these artefacts from discussions with students, staff and my own observations. I also found it useful to source opinion and impressions from "outsiders" or newcomers in order to make the familiar, unfamiliar. I recognised that long exposure to an environment had the potential for behaviours and practices associated with artefacts to be "taken for granted" by members of the culture.

### 3.3.5 Data analysis

As I stated earlier, my data analysis was occurring in parallel with my data collection rather than as a separate process. My preliminary analysis aided identification of recurring themes, unanswered questions, and issues which needed clarifying, and guided data collection. As the volume of my data grew from the multiplicity of data sources, so did the challenge of organising and finding meaning that would lead me through the levels of analysis to theory development and answering my research questions.

Two factors in the data analysis process were important to ensure the validity and originality of my research: firstly, that the analysis processes were transparent and would provide a clear chain of evidence to support my findings and subsequent theory development; and secondly, that in conjunction with my acknowledged background and experience in the field, the processes of analysis should allow theory to emerge inductively from the data.

The iterative processes of analysing data that have been described as a feature of the interpretive research (Bogdan & Biklen, 1982; Merriam, 1988) were well illustrated in this study. The first round of data analysis of the interviews and questionnaires from completing students and staff consisted of immersing myself in the data, a task which was made easier by having personally conducted all of the interviews and transcribed the resultant tapes. Reading and re-reading transcripts, annotating them with potential themes and categories was followed by a series of activities including mind mapping categories and connections, physically cutting up transcripts and sorting by possible categories, and compiling matrices of themes and contributing sources of evidence.

Initially three major themes emerged – these were:

- engineering was “hard”;
- friends and mates were very important and valued;
- engineers had a strong sense of belonging to a collective identity.

Further delving gradually surfaced the theme of:

- engineers were taught and learned a common way of thinking.

Referring back to the questionnaire responses confirmed these themes and the variety of understandings within them. After referring these tentative themes back to some of the original participants and discussions at a conference where they were presented as initial findings (Godfrey, 1998a) I proceeded to the analysis of data from first year students. By this time, the interconnections between themes and categories had become quite complex and I felt a more comprehensive and rigorous method of data analysis would be valuable. I made the decision to use an inductive coding system to analyse the student interview data. One requirement of the system I would use was that the coding system would be able to incorporate data from the multiplicity of other sources I had gathered. Any coding system used would also need to fit with my theoretical framework in which my data were providing me with evidence of Schein's first level, the observable practices, behaviours, events, and in particular the shared understandings and knowledge of the participants.

Miles and Huberman's (1994) comprehensive text on qualitative data analysis suggested that codes were tags or labels for assigning units of meaning to "chunks" of varying size – words, phrases, sentences or whole paragraphs. The data were words but it was their meaning that was of importance. The use of codes would enable me to retrieve and organise the "chunks" in ways that would relate to a particular research question, construct or theme.

Codes could be created, at least in part prior to fieldwork, using either 'a priori' knowledge and concepts gained from experience and the literature, or by inductive coding techniques, comprehensively described in Strauss and Corbin (1990). The inductive or grounded theory approach implied written data was examined line by line, allowing categories or labels to emerge. Miles and Huberman (1994, p.61) suggested an approach used by Bogdan and Biklen (1982) as partway between these approaches, using a coding scheme which was not content specific, but which initially pointed to general domains in which codes could be developed inductively. Bodgan and Biklen suggested codes grouped around the following categories:

| | | |
|---|---|---|
| *1.* | *Setting/Context* | *general information on surroundings* |
| *2* | *Definition of the situation* | *how people understand, define or perceive the setting* |
| *3.* | *Perspectives* | *ways of thinking about the setting "how things are done here"* |
| *4.* | *Ways of thinking about people and objects* | *understandings of each other, outsiders, or objects in their world* |
| *5.* | *Process* | *sequence of events, transitions, changes over time* |
| *6.* | *Activities* | *regularly occurring kinds of behaviour* |
| *7.* | *Events* | *specific activities, irregular* |
| *8.* | *Strategies* | *ways of accomplishing things* |
| *9.* | *Relationships* | *cliques, romances, friendships, enemies* |
| *10.* | *Methods* | *problems, joys, dilemmas of research process* |

These coding categories were intended as starting points. In any set of data not all would necessarily be present, some would overlap and the list was not intended to be exhaustive. Within these groupings, however, codes specific to a study could emerge.

I undertook the mechanics of this coding process by the following steps:

1. I identified how these coding groups might apply in the context of my study and named them in ways that were meaningful to my study e.g. Perspectives, for me became "how people thought about the academic learning environment" and I named the overall code for this group AC_.
2. I converted the word-processed files of my transcripts to a table format, which could include code and comments.
3. I read every interview carefully, identifying line by line whether the comment had significance culturally, and, if so, which of my overall coding categories it might fit into. Codes were added or assigned at sub theme level as this process continued. It was possible for data to be assigned to more than one code. An example of a piece of coded data is given below:

| | | |
|---|---|---|
| "also because it is a scientific course and the strength of wood is objective thing whereas in Arts when you are studying Shakespeare, you get a million ideas and if you argue your point it is right" | EN_WAY | *Engineering is objective not opinions* |

This stage of the analysis was critical to further theory development, because it was at this stage that I was required to, in Merriam's words (1988), "mine" the rich and detailed interview data to extract meanings and understandings which would contribute to my research questions. This stage was at the heart of the inductive theory approach and, although my background and experience meant I was alert to cultural features reported in the literature, I was also conscious of allowing the data to present unexpected or new perspectives.

4. Codes were not static but I revised, added to, discarded and coalesced them as my analysis continued, and my confidence with the technique grew.
5. In much the same way as a manual cut-and-paste technique, I brought together the “chunks” of data pertaining to each code and kept them in one electronic file, labelled with their source. This process was laborious but worthwhile, as quotations which would later be used as evidence in my report were accurate in both source and text, did not require retyping and were grouped around themes which were likely to be used to report my findings, and develop the further levels of culture analysis.

Some codes were relevant only to first year students, and others to final year students. I have presented a complete list of the coding groupings, and codes used in Appendix 10.

After coding all of the interviews, and conscious of other sources of data which were also contributing to the themes which had emerged, it was timely to position my findings on my theoretical framework and move to the second level of the theory development, the identification of the cultural values and norms. In the next section I discuss ethical considerations of my data collection and analysis before moving in section 3.4 to discuss the framework for the second and third levels of theory development.

### 3.3.6 Ethical Considerations

The main ethical considerations of case study research are informed consent, confidentiality and potential harm to the participants.

When so much of my data collection would entail participant-observation, informed consent from the School of Engineering was an essential precursor to data collection. As implied earlier I discussed my Research proposal with the current Dean of the

School of Engineering and sought his permission to gather data. At his suggestion, I made a presentation at a Faculty meeting, prior to data collection, to enable staff to ask questions about my methodology and objectives.

I sought informed consent with respect to all data collection, by providing all participants, by interview and survey, with a background to the research methodology, goals and objectives. I provided them with information regarding procedures that would be adopted to ensure confidentiality, including the storing of all research data at my personal residence, and gained their written permission for excerpts from their taped transcripts to be used as evidence. I took particular care to preface specific enquiries and requests for informal feedback by acknowledging that I was adopting my role as researcher at that time. My field note diaries kept note of observations and casual conversations, but were used as spurs to further data collection, or feedback requests and only rarely used as direct evidence in the presentation of my findings. Anonymity of the participants was especially important when the case study institution itself was identifiable and for this reason I have not provided details of the participants. I used code names such as Sstaff4 (signifying a senior academic staff member) for staff and self-selected pseudonyms for students. Some students chose pseudonyms which indicated their ethnic origins, but in the main their pseudonyms indicated only their sex. I labelled questionnaire data to indicate the sex of the respondent eg Questionnaire M25.

I also sought to minimise potential harm for participating staff members and students. One result of this concern was my deliberate decision not to focus in depth on aspects of gender issues for staff members because of the likelihood of invading the privacy of the very small number of female staff members. To counter ethical concerns relating to the identifiability of the case study institution and release of data into the public arena, I adopted a variety of information disseminating methods including a seminar, and electronic distribution to staff members of preliminary conference presentations.

I was particularly conscious of Bell’s guideline (1993) for insider research, namely, the need to maintain strict ethical standards at all times, never assuming “it will be all right”.

### 3.3.7 Validity and Trustworthiness

One of the goals of this research was for my research to be accessible and acceptable to engineering academics. As I stated earlier, the majority of engineering educators are familiar with the positivist research paradigm. In this paradigm, considerations of validity, credibility, generalisability, and objectivity are all important, although the supposition that any research is totally objective or unbiased has been challenged (Erlandson et al., 1994, p.252). It appeared to me that it was especially important that this study, whilst true to the nature and needs of the interpretivist paradigm, could be seen by my engineering colleagues to satisfy the tenets of rigorous research, albeit qualitative rather than quantitative. An overriding criterion for trustworthiness in interpretivist research was not the number of participants or precise number of times a particular statement was made, but the depth and quality of the observations from the participants, combined with the quality of the researcher's (my) interpretive abilities.

As discussed below, my research design and methodology has, I believe, satisfied the four main criteria of validity and trustworthiness for qualitative research, namely (a) credibility (b) dependability (c) transferability and (d) confirmability (Lincoln & Guba, 1985).

#### *3.3.7.1 Credibility*

The criterion of credibility or internal validity is the degree of confidence in the 'truth" the findings have for the participants in the case study institution. A reliable interpretation of the participants' lived experience was assisted by my prolonged engagement with the site and personal relationships with many of the participants. This allowed for on going feedback and discussion to clarify and verify interpretations.

I used member checks and cycles of feedback at several points during data collection and analysis. I presented a seminar open to staff from Engineering and other academic disciplines, on the progress of my research in October 1998.

Approximately 30 staff, including both academic and general staff attended the seminar. I circulated draft copies of three conference papers, presented on the interim results of my research, to the Dean of the School and several staff for comment, to test validity and credibility of the findings before presentation to a wider audience. I invited other staff to read copies of these papers posted on my personal web page. I then presented several conference papers of "research in progress" at international conferences to both engineering educators and women in engineering advocates, to validate my developing themes and theoretical findings. In 2001, I presented a seminar to Faculty of Education colleagues to report and seek feedback on the development of my theoretical model.

I sent the first year students interviewed at the end of 1998 an e-mail summary of my initial research findings asking for confirming or disconfirming comments. I also advised them of the website location of my conference paper dealing specifically with these findings. The final year and graduate students interviewed in 1997 and 1998 were also notified of the location of the papers prepared as a result of their interviews and I re-interviewed several for further comment and feedback in 2001 as my theory became more developed.

In describing my data collection methods it is apparent that I have used methodological, data and time triangulation to ensure multiple opportunities for reinforcement and confirmation of my findings as well as highlighting divergent themes.

#### *3.3.7.2 Dependability*

There is some overlap in meaning between credibility and dependability. However, dependability in qualitative research has been suggested by Lincoln and Guba (1985, p. 288) to be judged by whether an outsider would concur that, given the data collected, the results make sense – they are consistent and dependable.

As well as the field notes diary mentioned earlier, I kept a separate diary throughout the study, which tracked the processes, logic and literature that directed my research design, data collection and analysis through to theory development. In this diary I recorded, for example, comments after each interview, noting themes that had been re-iterated, new issues that had arisen, and how these new issues might be followed up, either by incorporating additional questions in further interviews or by seeking out new interviewees who might bring confirming or contradictory perspectives. I also recorded the on going development of codes for interview analysis, described in section 3.3.5 in this way. This research diary provided a comprehensive audit trail of my study.

To ensure my results were dependable I have:

1. made transparent my position relative to the group, the basis for selecting informants, and the context in which the data were collected;
2. used methodological, data and time triangulation to strengthen dependability as well as credibility;
3. provided a clear chain of evidence that would enable an audit trail at all steps of my data collection, decision making and analysis.

#### *3.3.7.3 Transferability (external validity)*

External validity or transferability is concerned with the extent to which the findings of one study can be applied to other situations. Merriam (1988, p.173) warned against using the case study approach to generalise from one case to other cases, when the aim of a case study is to “understand the particular in depth”. I have discussed the application of generalisation in the use of case study research earlier in 3.2.1. My aim in this study is not to generalise the unique culture of this institution to other institutions. Rather, my aim is to provide an in-depth analysis of the engineering education culture at the case institution from which I can define the dimensions of the discipline culture and expose the interaction of gender within that culture. The transferability of my research lies in my development of a model for cultural analysis, and a set of cultural dimensions for engineering education, which have the potential to enable other institutions to similarly examine their own unique manifestation of the discipline culture.

A detailed description is given in this chapter and as part of the results in Chapter 4, which places the chosen site for this case study in a variety of contexts including time, place, demographic environment etc. By fully describing my research setting, the applicability of my findings, to another site can be gauged.

#### *3.3.7.4 Confirmability or Objectivity*

Lincoln and Guba (1985, p. 290) suggested that confirmability or objectivity was the extent to which findings are the product of the inquiry and not the biases of the researcher. In this chapter and in the forthcoming analysis I have described a clear chain of evidence that not only linked data to their sources, but also provided the logic used at each step to assemble my interpretations into a coherent model.

Because of the acknowledged subjectivity of interpretive research I recognised the likelihood of issues being raised concerning the classification of themes arising from the data analysis and choice of quotations to illustrate them. To counter one aspect of this area of possible bias, on several occasions I used as "peer debriefers" two colleagues with a background in qualitative research (one of whom was an engineer), (Erlandson et al., 1994, p.31). They reviewed selected transcripts and coded them independently. I then compared their interpretations with my own for alternative perspectives, verification and refinement.

## 3.4 Formulation of a model – framework for levels of analysis

As my data collection progressed, the quantity of data obtained from the multiple sources grew. Simultaneously themes and categories emerged from the coding process. A challenging feature of the next stage of my analysis was to report/organise these findings in such a way that, as my analysis proceeded to the deeper levels of culture, the chain of evidence was transparent and reliable. I was guided by the truism, that "when data accumulate, refer back to your research questions and theoretical framework".

Schein's theoretical framework (1985), outlined in detail in Chapter 2, had named the first level of a culture as artefacts, the observable and experienced manifestations. He suggested artefacts incorporated behaviour patterns, day-to-day practices and organisational structures. Other cultural theorists have referred to symbols (Hatch, 1993), stories, heroes, rituals (Hofstede et al., 1990) and language (Brown, 1995) at this outermost level of culture.

My evaluation and interpretation of my data led me to the suggestion that even within this first level of observed and experienced manifestations of culture, there were sub-levels of analysis. Firstly, there was the level visible to a visitor or newcomer: buildings, publications, dress. Secondly, after a longer period of observation and investigation, the structures and practices, including those which were not written rules or regulations, were exposed. Thirdly, after trust had been established, insightful discussions with members of the culture would provide information about behaviour patterns and the reasons behind them. I have therefore divided my data in relation to this first level of culture into three overarching categories of Artefacts, Practices and Behaviours for the purposes of reporting on my findings. In chapter 4, I have grouped those cultural features which are visible, material manifestations and symbols of the culture (such as written documents, mission statements, buildings and styles of dress), under the heading Artefacts.

The remainder of my findings at this first level have been grouped as Practices in Chapter 5 and Behaviours in Chapter 6. The words “behaviours” and “practices” might be considered to have overlapping meanings, so I see it as necessary to clearly define their use in the context of my study. Practice can be defined as “something done regularly or repeatedly” (Collins, 1994), and I have used “Practices” to refer to those aspects of the culture which represent “the way we do things round here”. Behaviour has been defined (Oxford, 1989) as “manner of conducting oneself” but also as “manner in which a thing acts under specified conditions or circumstances or in relation to other things”. It is this latter definition which seems appropriate to my study. In my study I have, therefore, used Behaviours to mean the actions and reactions of the participants to other people, systems and procedures, including their responses to the “practices” and “artefacts”. In many instances I have used the grouping Behaviours to encapsulate the “lived experience” or “enacted” aspects of the culture. It was increasingly evident from my data that Geertz’s (1973) description of culture as “webs of significance” was manifested by overlapping and almost inextricable interconnections between the Artefacts, Practices and Behaviours.

I have amended Schein's diagrammatic model of culture analysis to include my evolving understanding of: firstly the interconnected layers within the outermost, observable level of culture and, secondly, the dynamic relationships between the levels of culture. This model, presented in Figure 3.1, has guided the rest of my study and will be discussed further in chapters 7 and 9 as my research questions are answered in the light of my findings.

In chapters 4, 5 and 6 following my findings at the first level of the culture I have identified the cultural values and norms which these artefacts, behaviours and practices appear to manifest. This was the second level of analysis on Schein's framework. His third level was the uncovering of the less consciously held beliefs and assumptions which he saw as the essence and underpinning of a culture.

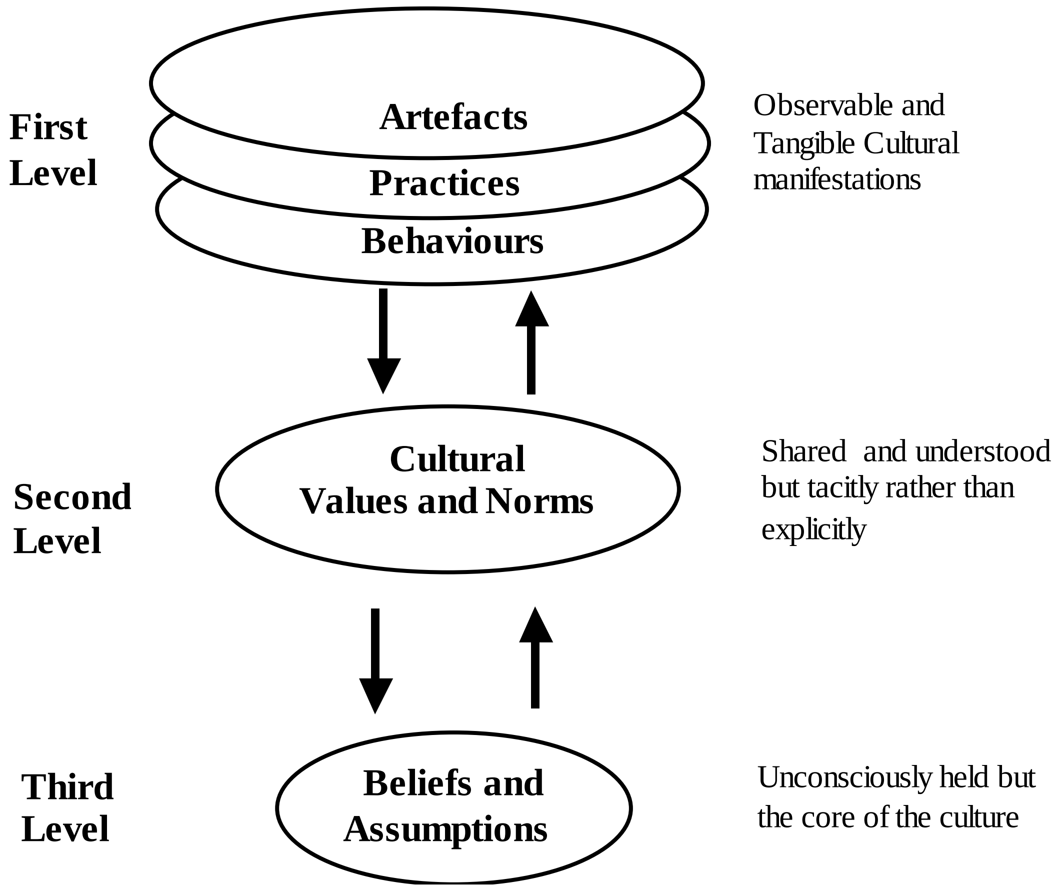


Figure 3.1 Proposed framework for cultural analysis (amended from Schein, 1985)

At this third level, Schein (1991) suggested that shared beliefs and assumptions form around cultural dimensions which address "issues of external adaptation and internal integration". Working from the findings of Chapters 4, 5 and 6, in Chapter 7 I have proposed seven cultural dimensions appropriate to engineering education, to interpret and put forward the beliefs and assumptions that were the essence of the culture of engineering education as evidenced in the case study institution. I interwove the interaction of gender at each level of the analysis throughout all of these findings.

In answering my first two research questions, I looked for shared values and norms. Consequently the perspective of Chapters 4 to 7 is that of an integrated view of the culture – recognising, as noted in Chapter 2, that the contributions and experiences of individual members may not have been identical. To answer my third research question, evidence that suggested a more differentiated culture, or the existence of subcultures, will be identified and discussed at further length in Chapter 8.

## 3.5 Summary

This chapter has outlined my use of an interpretive case study approach using ethnographic methods to collect data directly related to my research questions. I have included a full account of the procedures used for collection and data analysis, together with discussion at each stage relating to issues of trustworthiness, and ethical considerations. A model for the analysis of culture has been proposed, based on Schein's theoretical framework, to enable my findings to be used in succeeding chapters to answer my research questions, and build a theoretical model of the culture of engineering education from which issues of practical significance to gender may be addressed.

# Chapter 4

# Artefacts

## 4.1 Purpose and outline of chapter

This is the first of three chapters in which I explore in depth the artefacts, practices and behaviours, which collectively form the observable and tangible manifestations (the first level) of the culture of engineering education in my case study institution. The purpose of these three chapters is to provide answers to the first and second of my research questions. As I explained in section 3.4, my model splits this first level of culture into three sub-levels, artefacts, practices and behaviours, and I deal with each sub-level in a separate chapter. An important finding of my study, however, is the extent of overlap and interaction amongst these three sub-levels. Thus, while my primary focus in this chapter is on artefacts per se, I note behaviours and practices that have in some instances become associated with or perhaps developed because of, those artefacts. I have used the evidence provided by these behaviours and practices in the analysis of this chapter rather than in Chapters 5 and 6 because they demonstrate the relationships between the artefacts and shared values and cultural norms.

As proposed in Chapter 3 I have defined Artefacts as the visible, material manifestations of the culture, those aspects of the culture to which an outsider or visitor might have access, such as buildings, dress, publications, and website information. Confirming my own interpretations of the cultural nature of these artefacts with the members of the culture, I identify at the second level of analysis, the shared cultural values and norms which they appear to manifest.

The first section of this chapter is an examination of mission statements and strategic plans, followed by sections dealing with publications, buildings and facilities, art works and memorabilia, dress and finally the composition and characteristics of the staff and student body.

## 4.2 Mission/ Strategic Plan/Governance documents

Mission statements have become part of the higher education discourse in recent years. They are available in publications, on websites and sometimes in frames on walls. Their importance to a culture is that they are most likely to have arisen from discussion and debate, and, in this sense, they embody shared values, visions and commitment. Mission statements provide evidence of the espoused values of the group without commitment to specific actions or cultural manifestations (which should come later, at the strategic planning stage). Examining whether these espoused values and goals are matched in the reality of day-to-day practices and behaviours is crucial to a cultural study. I discuss the extent of this in Chapters 5 and 6 where I report on practices and behaviours.

The School of Engineering is located within the larger U of A community. The values and goals of the wider university inevitably shape those of its faculties through rewards and sanctions, budgetary prioritisation and other measures. At the time of the study the University had espoused a mission, and established goals and strategies for a wide range of university activities in what was known as the Mission 2001 statement [1]:

> *To enhance the position of The U of A as a university of high international standing, recognised for excellence in teaching, research and administration, innovative contributions to the advancement of knowledge, and service to its local, national and international communities.* *Mission 2001, 1996*

Specific institutional values were listed, and included:

> *The U of A is committed to:*
> *Conserving, advancing and disseminating knowledge through teaching, learning and research of the highest standards….*
> *Creating a diverse, collegial scholarly community in which individuals are valued and respected, academic freedom is exercised with intellectual rigour and high ethical standards…*

Excellence in teaching and learning was to be achieved by strategies such as:

> *…providing a student-focussed teaching and learning environment which encourages academic excellence, enjoyment of learning, critical reasoning and inquiry…*

The School of Engineering had been criticised in the IPENZ 1995 Accreditation Report as "having a series of plans, but no integrated plan for the future…" and,

[1] http://www.auckland.ac.nz/auabout/goals.html#Foreword

following the Mission 2001 document, the committee of Heads of Department, in 1997, prepared a Strategic Plan. The draft document presented to the Faculty of Engineering in May 1997 made reference not only to the Mission 2001 statement and the IPENZ Accreditation Report 1995, but also the IEAust Review "*Changing the Culture: Engineering Education into the Future*" (IEAust, 1996).

The vision for the School of Engineering (or mission) quoted in the 1997 document was:

> *To move from being a very good School of Engineering to an outstanding school – the pre-eminent provider of professional engineering education in New Zealand, known nationally and internationally for the quality of our teaching and research.*

Early in the 1997 Strategic Plan is the statement:

> *A special feature of the School and one which distinguishes it from many other engineering schools is the close integration of the five departments. This plan is based on the* ***overriding assumption*** *that inter-department activities in both teaching and research will continue to be an important part of the culture of the School.*

The bold font in this statement is my own emphasis, to highlight the strength of the value this Strategic Plan placed on interdepartmental integration. Closely allied to the University Strategic plan in style and layout, the engineering document included goals for Teaching and Learning:

> *To promote high quality learning for engineering students led by staff who are committed to excellence and the pursuit of knowledge*

Clear strategies were outlined which included:

> *To continue, on a regular basis, to use the best means available for evaluation of teaching and learning quality and obtaining student feedback*
> *To encourage and fund staff in new teaching initiatives*

This draft document was discussed at a Faculty meeting (May, 1997) with the themes of the discussion listed below:

- Many of the goals hinged on funding and funding hinged on whether a policy of growth in numbers was needed, and the consequent implications for buildings and resources:

> *…need $$ or we cannot do any of these things.*
> *…need to agree on 'growth' first and everything else follows*
> *Faculty meeting, May 1997*

- A strong sense of "going it alone" if necessary – acting as a faculty independent of the rest of university:

> *…too much waiting for the rest of the University to tell us what to do …*
> *…have to accept that the people who will carry this out will be us – no one is going to do it except us …* *Faculty meeting, May 1997*

- Strong agreement on maintaining entry standards.

The discussion produced no timelines, designated responsibilities or reporting back mechanisms and, over the five years since 1997, the document and its goals have not resurfaced in the original form.

A change of leadership in early 1998 resulted in a document put forward by the new Dean in November 1998 "*A vision for the future*" which reinforced many of the ideas of the 1997 document. In particular, it again emphasised the maintenance of the perceived position as the "pre-eminent engineering school in New Zealand"[2] and the strength provided by the large amount of interdepartmental interaction, cooperation and activity.

The measure of success for the School was described in this document as embedded in the School's reputation, both nationally and internationally, in the areas of teaching, research and community service. Of these, the new Dean saw teaching as the most important, because of the total impact on society of literally thousands of graduates acting as practising engineers and/or doing research.

The new Dean made special mention of the importance of the student culture of the school, including social life, workload, friendships, interaction with lecturers and the overall "friendliness" of the place. A manifestation of the value he placed on this aspect was the formation of a Faculty committee, the "Student Issues Committee", with staff and student representation that was to address both academic and social issues. Reinforcing this commitment, I noted that the committee has been the route for providing funding and resource assistance to a wide variety of student groups.

2 paper presented to Policy Group, " A vision for the future", Dean of Engineering, November 1998

The draft "Vision" document was discussed at a Faculty meeting but never converted into a formal Mission Statement and Strategic Plan:

> *We do a lot of planning, and thinking of the future – we just don't get around to putting it onto paper, like Mission statements and strategic plans and that sort of thing.*
> *HOD4, Nov 2000*

### 4.2.1 Commitment to recruitment and retention of Women in Engineering

Since the early 1980s the School of Engineering had a publicly stated goal ofincreasing the participation of women. The "Message from the Dean" in the 1983 Prospectus commented "all engineering courses lead to a wide range of challenging and interesting careers… what we would like to see is a substantial increase in the number of girls selecting engineering". This support and commitment to women in engineering was commented on in the 1995 IPENZ Accreditation Review:

> *The proportion of women students studying engineering has risen dramatically as a result of considerable effort put in by the faculty over the last fifteen years. … The appointment of … as Liaison Officer for Women in the Physical Sciences and Engineering and her location within the school has been the most important factor in increasing the awareness amongst girls that Engineering can be an attractive career for them (p.19, Vol 1 Introduction, documentation for 1995 IPENZ Accreditation)*

The School of Engineering 1997 Strategic plan quoted earlier in this section explicitly included this commitment with the objective "To continue to foster under-represented students studying engineering" and strategy "To build on the strengths of existing work in fostering women students to study engineering".

The documents quoted here, such as the Mission Statements of the University and the Strategic Plan for the School of Engineering, are the visible manifestations of the values that the School of Engineering aspires to. In brief, these documents portray aspirations to excellence in all aspects of operations (including teaching and research), with an emphasis placed on the integrated nature of the School.

## 4.3 Publications

In common with most educational institutions, the School of Engineering produces a large variety of documents and publications. These include: faculty and committee minutes, research proposals and reports, annual reports, accreditation documentation, specially commissioned reports, course notes and examination papers. The majority of these documents are produced in-house for specific information transfer to staff and students. Their value for this study lay in the insights they provided into the normal day-to-day practices and norms of the case study institution.

Publications of educational institutions are usually ‘branded’ with an official crest or logo, which often gives symbolic clues to traditions or perhaps a desired image. All letterhead and publications of the School of Engineering included the University crest, which was a traditional heraldic crest with a Latin motto “Ingenio et labore” in the manner of traditional British or European institutions. During the 1990s several attempts at designing an Engineering specific logo were proposed. Redesigning the website provided a suitable opportunity and in 2000 a logo was approved that incorporated a toothed wheel running into the ‘koru’ pattern of an unfolding fern frond (a New Zealand symbol of growth and potential). This logo was used on the website and printed material, incorporating a variety of pictorial images (e.g. Figure 4.1).

Figure 4.1 School of Engineering logo proposed for new website

At the time of writing it was too soon to predict whether this will become a cultural artefact but it could well become a symbol of the School’s values and goals if members of the culture develop shared understandings of what it represents and identify with it.

Two types of publications which seemed to me to be of particular importance as artefacts, were publications produced primarily for recruitment and marketing purposes, and publications produced by students, for students. In considering these publications, I noted that there was no guarantee that they reflected shared values and beliefs as manifested by behaviours and practices, but to an observer they could be seen as a reflection of the culture, and the opinions and values expressed were likely to be viewed as representative of the institution.

### 4.3.1 Faculty publications

During the years of this study (1996 – 1999) the faculty produced three annual publications relevant to undergraduate study. Each was aimed at a different target audience. These three publications were a brochure/flyer, a Prospectus and a Handbook.

The brochure and Prospectus were for external use, as recruiting and marketing tools. The brochure was a relatively cheap "giveaway", distributed widely at career expositions, schools, Open Days or other such occasions. It was intended to be eye-catching, and appealing to a wide audience, but predominantly one of high school age. The aim was to present the School of Engineering as a welcoming, exciting place, and the engineering degree as a pathway to a challenging, rewarding career. The publications committee, of which I was an invited member, tried to ensure that the message sent by the publication was positive yet true to the institution. In the late 1990s the images and messages became more important, as marketing increasingly became an important arm of university recruitment. The brochure provided a brief glimpse of the structure of the degree and emphasised the range of careers that might follow engineering study using previous graduates as role models.

The Prospectus was targeted at more committed prospective students, those who had made a specific request for information and who might apply the following year. Its prime purpose was to inform people about entry requirements, course structures, and the range of courses within each engineering discipline. It was much more detailed than the brochure but still intended to attract potential students.

The Dean's message included in both the brochure and prospectus conveyed the School's view of engineering and its purpose. In 1996 and 1997 the message included:

> *Engineers make things happen in society – because of engineers we live better lives … the engineers of today, tomorrow and the next few decades must be capable of managing the technological developments of the twenty first century.*

The language was entirely gender neutral – portraying engineers in an influential, active role, serving society.

In 1998 the message included the addition of creative problem solving to the role of service:

> *Professional engineers are the women and men who work on creative solutions to the ever changing needs of society and our environment.*

In 1998 also, it was made explicit that the curriculum was responding to the demands of the engineering profession by introducing courses in:

> *…management, professional development, environmental issues and an increased component of project based learning without losing the high standard and depth of technical material of a professional engineering degree.*

Also made quite explicit in this message was the value that the School of Engineering placed on having "all sections of our community represented within the profession" and its continuing commitment to increasing the participation of under-represented groups such as women, Maori and Pacific Island people.

In 1999, the new Dean's message continued the themes of earlier years and added that "our students are being trained to a pragmatic analytical way of thinking".

Figure 4.2 Photo of testing of first year truss project

Visual imagery also contributed to this public affirmation of how the School of Engineering saw itself and engineering education. Notably, the visual imagery focused on presenting a human face to engineering, with the majority of the photographs having students and staff actively engaged with some aspect of project or experimental preparation, or the range of projects, industries and research with which engineers are involved. Examples of student projects such as the first year truss project (Fig 4.2), the steam car competition (on cover, Fig 4.3) have been popular photo opportunities emphasising the practical creative side of engineering. Images such as a model of the flow in an artificial ventricle (1998 prospectus), and a 3-D computer graphics model of the eye for a virtual reality system used in microbiotic surgery (1995 prospectus) not only provided spectacular colour images, but hinted at the application of computer modelling and simulation as leading edge technologies.

#### *4.3.1.1 Images of women*

Efforts to ensure that engineering was seen as welcoming to women were confirmed from the images in the prospectus. The 1996 prospectus had ten people on the front cover montage (Fig 4.3) and four of these were women. A female prize winning graduate and design analyst with Team New Zealand (the winners of the Americas Cup in 1995) was one of them. Another showed a young man and woman in graduation regalia toasting their success and a group photograph taken in the gym of an engineering basketball team, which included 2 young women.

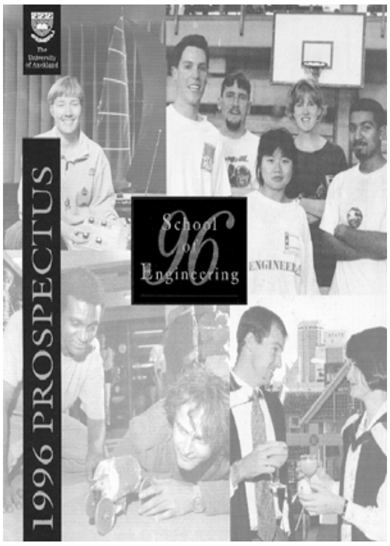


Figure 4.3 1996 Prospectus cover

The 1997 prospectus continued this trend with half of the photos including women. The University mediator congratulated the Associate Dean at the time:

> *…the 1997 prospectus is the most positive in terms of representation of women and ethnic minority groups that I have seen to date (private correspondence 30/9/96).*

These publications portrayed women as active and involved members of the student body without comment or fanfare that they were in any way unique or special.

The Engineering Handbook had the primary purpose of providing information for already enrolled students, eg course catalogue, timetables, assessment information, policies on cheating, practical work experience requirements, book lists and scholarship lists. It was produced at relatively low cost, with little attempt to include photographs or visual images. It was functional, readable, clear and accurate and students were recommended to "Keep it available for easy reference" (p. 2, 1995 Handbook). The Associate Dean referred to the Handbook in his Orientation Day speech (March, 1998) as "your Bible – with answers to all your questions".

These faculty publications provided information to a cultural observer about the context in which the engineering culture is formed and maintained. They manifested the values, beliefs and attitudes around engineering education and its preparation for the profession that the institution wished to be seen as having – their espoused values and beliefs. In summary these were:

- That the Engineering degree was a very worthwhile educational preparation for a profession which has a unique role in serving the ever changing needs of society and the environment;
- That the curriculum prepared students for the needs of the profession with a balance between technical knowledge and professional skills such as communication, teamwork, management and generic problem solving;
- That all sections of the community should be represented within the engineering profession.

I consider the question of whether these values and beliefs were part of the lived and enacted culture in the chapters on Behaviours and Practices.

### 4.3.2 Student publications

The student Engineering Society, which professed to represent all engineering students, produced a newsletter *Enginuity* once or twice a year, which varied in quality and length depending on the time and budget of the students responsible. There was no continuity or flow between the publications, and each edition tended to be a "one off" publication predominantly filled with jokes. No censoring by staff occurred and only rarely was the publication censored by the committee of the student society. The intent of these publications appeared to be to instil or reinforce a sense of pride and identity in being an engineer:

> *Congratulations on choosing one of the more difficult and functional of University qualifications* *Enginuity, May 1998*

The majority of the jokes appeared to have been taken from other publications or from the internet and took the form of:

(a) depicting engineering students as special and other students as useless:

> *Join the most elite group of individuals in the universe defined in the Oxford dictionary as:*
> *Engineer n. Master, demi-God; leader of man and ruler of earth. Any inferior students (arts, commerce, law etc) should send no money now,,, All you need is a calculator, a check shirt and a superior mental capacity to joint the ranks of the obvious choice for human evolution.* *P.19 Enginuity May 1998*

(b) reinforcing the perceived qualities of an engineer:

> *…you know you are an engineer if:*
> *you consider any non engineering course easy*
> *you'll assume a 'horse' is a 'sphere' in order to make the maths easier*
>
> *Normal people believe 'if it ain't broke don't fix it', engineers believe 'if it ain't broke, it doesn't have enough features yet'*

(c) focussing on stereotypical male images – predominantly including a preoccupation with alcohol:

> *The BE conjures up carloads of connotations to me, some of which are based in fact: BE a pisshead, BE a computer genius, BE a laid back bloke, BE a blokey woman, BEer, BE slow to mature…BEer is happiness*

and

(d) sexual and/or scatological innuendo and humour.

In the latter sense, the editor of the September 1998 *Enginuity* commented "I apologise in advance to all female readers for doing what I had to do – cater for a predominantly male faculty" above a "photo" of the Spice Girls naked. An eye-catching headline in the March 1996 *Enginuity* was, "Computers – Why the internet is like a penis".

A stereotypical, social identity of engineering students was promoted in these publications as if it represented the majority:

> *Work hard, play hard – that is the unofficial motto in the E school. The social culture that surrounds the E school is at best notorious …… Suffice to say that kicking back and ignoring the pressures of, what is, a pretty intense degree by knocking back a few glasses, jugs, kegs of your favourite poison is none too bad a way of spending an hour/day/week* *p.16, Enginuity 1997*

The Female students that I interviewed at the end of their first year identified that this student publication was popular and they identified with the "engineering identity" portrayed. Rebecca commented:

> *Lots of people read the magazine – there weren't enough copies put out! It was actually quite good, lots of in-jokes but I guess you get that with school or departmental things. There were some interesting, very accurate and very funny pieces… like the "you can assume a horse is a sphere in order to model it mathematically" especially after our first Math Modelling assignment which required us to model a human being first as a cuboid, then a collection of cuboids, then a collection of cuboids, spheres, cylinders etc in order to approximate the volume and skin area of a body"*
>
> *Rebecca, October 1998.*

No comments were volunteered by these female students about the sexual imagery involved and, when asked if they noticed it, the response was "yeah, well… I mean what can you expect… that's life isn't it…" (Rebecca, Oct 98). I only noted one occasion when a female student protested, (Diary1, March 1996). Her protest, in her role as Student Society President, was that the editor had deliberately added content which might be offensive to females after the rest of the magazine had been approved.

In my experience, student publications have for many years intended to shock and these publications were no exception. These Engineering student publications, however, valorised a particularly "blokey" form of masculinity and linked it to excessive consumption of alcohol to a degree I had not seen in any other student publication.

The profiles of the student Executive Committee in the *Enginuity* of May 1998 appeared to me to highlight female students as "different". Two female students were joint Treasurers and their profile read:

> *As the voice of reason and moderation, these **girls** have a difficult job this year. They must make sure the alcohol budget is maximised within financial parameters. **As females**, they are genetically gifted communicators and organisers (according to the new (female) head of IPENZ), so we are all happy to have them on the team!*

The bold font is my own. All the male members of the committee were spoken of by name eg "An able organiser, Kev works hard…", "as the token Electrical student, Dunk is…". The author singled out their gender only for Ruth and Terri, whose photos were provided. Was it not obvious that they were female? The childish term "girls" was used – then later they were females – it was their biological sex that was being commented on, followed by a snide reference, taken out of context to an article that had appeared in the IPENZ Engineering magazine.

Whilst I recognised the immaturity of the author, and it seemed obvious that the author was a male, I questioned whether comments such as these displayed an inability to see female students as "student engineers" first and females second. And why was it deemed acceptable? Poking fun and "put down" jokes are common forms of humour often used to emphasise solidarity of the dominant group (Hacker, 1981; Lyman, 1987). By emphasising the obvious difference of their sex, I felt the female students were subtly, or perhaps not-so-subtly, being marginalised as "other", not "real" engineers.

Race or ethnicity was not mentioned, although gendered jokes were common e.g.

> *…females make the rules, the rules are subject to change at any time without prior notification but no male can possibly know all the rules* *Enginuity, May 1998*

Assumptions were made by the editors (male?) that this type of humour was condoned or at least not disciplined against in ways that racist slurs would be. It was clearly acceptable to include stereotypical sexual imagery. There appeared to me to be no understanding by the authors that female students may have felt belittled and/or repelled by this type of publication, and that other male students may also have found them offensive.

Attempts were made in the 1998 publication to include topical issues such as a change to voluntary student membership of the Society and discussion of the proposal to shift some departments to another location, but the space given to these issues was around one eighth of the total 24-page publication.

The stereotypes presented in these publications were viewed by many male and female students as "living in the past". As I discuss again later in Chapters 5 and 6, the Engineering Society represented a minority of the student body, but a very vocal and highly visible minority and the most visible image of engineering student culture. Any outsider or historian examining these student publications as manifestations of the student culture would identify the following as cultural norms:

- that engineering students had a sense of pride, bordering on arrogance, linked to their collective identity as engineers;
- that engineering students enjoyed the consumption of large amounts of alcohol as part of their social activities;
- that student publications valorised a very "blokey" form of masculinity as the norm for engineering students.

## 4.4 Buildings and facilities

For any institution, facilities comprise the buildings, the grounds and all the attendant facilities they house. They have a distinctive configuration, architecture and furnishings which make a lasting impression, particularly for someone visiting for the first time.

The School of Engineering was part of the largest university in New Zealand, on a central city site on the top of a ridge with a main traffic route running through the middle. The university buildings were very cramped and close together, and represented a range of architectural styles. The School of Engineering was housed in a building situated on a corner and across the road from the rest of the campus (Figure 4.4). Located on a steep hillside there were four linked buildings, each of five levels, housing laboratories, workshops, lecture theatres and tutorial spaces running down from the main entrance and a tower block of a further seven storeys which housed the offices of academic staff.

Figure 4.4 The School of Engineering building

For practical purposes, the heavy, technical workshops and laboratories such as the Concrete Testing Hall and the Fluids Lab, where quite large-scale working models of hydraulic and coastal engineering works are built, were located at the lowest levels. Computer labs and less “manual” labs were on the 3rd floor with administration and teaching spaces on the 4th and 5th floors. The tower block, commanding impressive views of the city and harbour, contained academic staff offices of all departments except one. The newest department, Engineering Science, occupied a specially built rooftop annexe.

The building itself, in common with other buildings constructed at the University in a period of rapid growth in the late 1960s, was functional rather than aesthetically pleasing. A utilitarian building, it was dominated externally by grey concrete and glass. The only outside open area between the buildings was concreted and rarely sunlit. One staff member described it as “a fine example of the architectural style known as horizontal brutalism” (Sstaff3, 10/9/00).

Entering the School of Engineering by the main entrance, the first impression of the foyer (upgraded in 1997) was bright, functional, well maintained and welcoming. The vinyl flooring and walls were in shades of blue and mauve, with the occasional greenery and a large number of tables with modern styled (but durable and bolted down) seating. The upgrading of the foyer was not matched, however, in the rest of the building, which was perceived by students as “getting rundown”, “the décor is badly in need of a revamp”, “grey and sterile” and “far from stimulating” (Questionnaires, 1997). My own first impressions of the lower levels in the late

1980s were of a confusing, dark, depressing area, full of unfamiliar machinery and equipment, a daunting prospect to visit. This impression lessened with increased familiarity and an understanding of the functions of the different areas. A student who had transferred to engineering after finishing a science degree commented:

> *If I take my friends through the engineering school, like walk through with me because I have forgotten something, they say things like "Oh it's so depressing in here, especially down in the lower floors, old and dingy" …It is just the decor really, it is amazing, the new offices upstairs are really nice, but a lot of the place is old and grey.*
>
> *Sally, 4th year C&M 1996*

### 4.4.1 All facilities are housed in one set of buildings

The physical facilities are artefacts in the terms of my definition, but it was the interrelationship with practices and behaviours and their relationship to values and norms which led to their importance as cultural features. For example, students and staff in engineering rarely needed to leave the complex of engineering buildings, which led to comments such as:

> *When you are doing engineering you are isolated into the building*
>
> *Sally, 4th year C&M, 1996*

Almost all teaching was done in-house, and labs, computer labs, workshops, a cafeteria and library were all contained within the School complex. As a result, both formal and informal contact between the different disciplines occurred regularly and allowed for the formation of close interactions and an overall identification with the School of Engineering rather than individual engineering disciplines.

The isolation from the rest of the university was a perception rather than a physical reality of distance, but a very common one with students and staff. Only one road's width separated the buildings from the main campus student gathering places, but I saw going "across the road" to have acquired a unique symbolism.

> *It's almost like we're proud of not going to the rest of the university –across the road, we say "Ooh, I'm crossing the road" as if it is sort of shameful…*
>
> *Karol, 4th year C&M 1996*

### 4.4.2 Student gathering spaces

Student gathering spaces had been identified in the 1995 IPENZ Accreditation Review as extremely limited, whether it be for purely informal relaxation or for study group sessions. The 1997 refurbishment of the entrance foyer to include tables and chairs, lap top connections and flooring and surfaces that allowed food and drink to be consumed, partly filled the need for such gathering spaces. I saw the foyer, which acts as the passage way from the entrance to all lecture theatres, used as a multipurpose hub – a place for meeting friends, a working area for small groups, the voting area for student elections, the venue for project group discussion meetings, and in one holiday session, the venue for a student's birthday celebration, cake and all.

> *…it is like a second home. Hang around the foyer and see someone I know.*
>
> *Teresa, 1st year 1998*

The foyer area was a welcoming and gender neutral place to sit and work or socialise, and I often observed undergraduate women students in this area waiting for friends or working alone. A female student returning for graduate study after approximately ten years commented that the "increased number of female students meant that you could walk into the foyer without heads turning", which had not been her experience as an undergraduate when "there were so few of us" (Diary, Nov 98).

The School of Engineering had its own Library facility. Students indicated, during both the 1995 University review and my survey of final year students (November, 1997) that environment issues (space, heat and noise) impacted on their effective use of the Engineering Library.

> *The library really needs improving – the atmosphere, temperature, noise, décor. (Staff are great!).*
>
> *Questionnaire M10*

Little change had occurred over the period of this research due to funding constraints. My observation was that staff in the library made regular 'low cost' efforts to make the library bright, cheerful and welcoming using greenery, and posters, and even balloons on special occasions.

Computer laboratories, increasingly in demand, were used as working spaces by students, with one lab open 24 hours after frequent requests for extended hours. Students complained to me that these labs, in which the priority appeared to be to fit in as many computers as is practicable, were in high demand, and that, after hours, there was nowhere available to spread papers out or discuss their work.

Although the School of Engineering had had its own cafeteria for many years, this facility, with no outside access or windows, and a pool table in the corner, was viewed as an unwelcoming place by many of the students, particularly the final year female students I interviewed, who had started their degree in the early 1990s.

> *It wasn't an ordeal for me to go down to the cafe but I can honestly see how it would be for some people – would just find it disgusting, especially a few years ago before they cleaned it up – they just recently put proper carpet – but before that I didn't like sitting in that area with the pool table it was just …* *Chloe, 4th year Mech 1996*

After several years of discussions with the Student Engineering Society, the café had been refurbished in 1997 within the limits of the building framework, and it seemed to me to be no more, or less, tidy than the main campus student eating places. At the time of this study I saw it used by a very diverse group of students, representative of the student body, at all times of the day. The billiard table in the corner was still dominated by male students, but I saw males of wide ethnic diversity, and female students join in from time to time. A wide range of food was available, and as one staff member commented "you can even buy sushi there now, that would have been unheard of a few years ago" (Jstaff1, Jan 98*)*.

Four years of close proximity with the building, and its association with friendships and shared experiences provided positive nostalgic memories for the majority of students interviewed and surveyed:

> *I love coming into the engineering school. I feel at home there and I love the way it has the name School of Engineering written above the door* *Geetha, 4th year E&E 1996*
>
> *What I liked best about the School of Engineering was…*
> *Everything we needed was under one roof* *Questionnaire F27, 1997*
> *It was separate from the rest of campus* *Questionnaire M16, 1997*
> *It has its own establishment* *Questionnaire M4, 1997*

As a consequence of this proximity a strong sense of identity and allegiance appeared to have arisen and behavioural norms had become associated in this culture with an artefact, the buildings and their facilities.

### 4.4.3 Staff gathering spaces

Any discussion I had regarding facilities and gathering places for staff inevitably brought comments about the Staff common room. There were three main gathering places for staff; one on the 12th floor of the Tower, one on the 4th floor near the central administration and library and the other on the 2nd floor close to the mechanical workshop. The location of these rooms (artefacts) appeared to me to have led to behavioural norms. The 2nd floor staff room was used almost entirely by male technical staff, the 4th floor staff room was used by library and administrative staff (predominantly female), and the 12th floor common room was used almost exclusively by academic staff:

> *General staff on 4th floor and technical on 2nd – terribly hierarchical – Some secretaries come up in the afternoon but they stay separate. If you really wanted a "common" room you wouldn't put it on the 12th floor – it would be more accessible. Even if you had a technician's corner. And research students should be able to be there. Does mean lost opportunities.*
> *Sstaff3, Sept 00*

The Dean responded to this perception in early 1999 when he sent an e-mail to all staff which commented:

> *A few personal thoughts about the 12th floor room –it is open to all staff, not just academics. There are other rooms that technicians and admin staff tend to use, which is fine, but all are welcome on the 12th floor. One of the greatest values of the common room is the chance for informal cross-functional and cross-disciplinary chat*
> *e-mail from Dean, 23/2/99*

It was the 12th floor Common Room which held a symbolic role in the life of the School. When staff spoke about the integrated nature of the school culture, it was common for them to take as an example the 12th floor Common Room, where all staff could meet and mingle over tea, coffee or lunch:

> *The provision of one common room for the whole School is both an outward symbol and a cause of interdisciplinary linkages; effective interaction between faculty members comes not from planning but from friendships and informal conversations where shared academic interests are discovered and intellectual cross fertilization occurs*
> *Dean, Nov 1998*

Comfortable chairs were arranged in rough circles around low coffee tables, with a couple of larger tables and chairs at either end of the room. Traditionally, staff brought their tea or coffee to the circle which was not yet filled, and only sat separately if they wished to concentrate on some reading, or have a private conversation. The room commanded a magnificent view of the harbour and an opportunity was always found to bring visitors to the common room.

Closer examination of the way this room was used (i.e. practices) made the "unifying" role of the Common room seem more of a myth than a reality. For a variety of reasons, which might include changing patterns of working, the increased time pressures on staff, personalities who have known each other for many years, and the presence of some dominant staff personalities, the numbers of staff who regularly used the common room at morning or afternoon tea times had dropped markedly over the last ten years. Out of an academic staff of 100 it was rare to find more than 20 in the room at any one time, and it was common to see staff come in, make a drink, and take it back to their room:

> *Over time a smaller and smaller fraction of the staff use the common room. Some people have quite regular habits – common room did provide at one time an inclusive forum for debating issues. Now it is a selective subgroup* *SStaff1, Jan98*

Younger women staff and postgraduate women did not often come to the staff common room alone, but usually with other women or departmental colleagues.

It was difficult to generalise this as a specifically gender issue, as young male staff and postgraduates also tended to come in small groups, but it was specifically commented on as a confidence issue by women.

> *Still some women who find it threatening and some young staff…* *SStaff3, Sept 00*

> *I don't socialise a lot upstairs. I don't feel entirely comfortable up there unless there are other women there. I don't feel I have things in common with…* *Jstaff2, Oct 97*

I observed that the comments about change in usage usually came from senior staff who had memories of a more leisurely time, when a common lunch hour was timetabled with no lectures, and 10.30am was morning tea time. I saw the room currently used from early morning until early evening, but in a range of ways other than the traditional. The nature of its use was now more like a "drop in" room with staff using the room as an alternative to their offices, away from distractions of phone or students. Small groups often met for work related discussions, including graduate students meeting with supervisors or research and teaching teams discussing current projects. Despite my inference that staff either didn't feel they had the time or didn't desire the company of other staff, I observed a strong loyalty to its existence as a shared place where staff from all departments could meet if they wished.

### 4.4.4 Teaching spaces

Despite the space constraints alluded to in the previous section, almost all teaching for Engineering took place within the School buildings. Timetabling teaching spaces had become a major challenge with increased numbers, and the introduction of the new Engineering specialisations of Computer Systems and Resource Engineering.

The academic staff responsible for timetabling classes put a high priority on keeping classes within the School buildings, and only looked for alternate teaching space as a last resort. The only classes taught off site were the combined core classes which were larger than 250 (the maximum seating space available within the School). This desire to keep classes on-site resulted in a deliberate choice to split a large class into two streams, rather than transfer those classes to a much larger lecture theatre "across the road".

The lecture theatres and tutorial spaces were all designed and built in the late 1960s and consequently they were almost all of the fixed seat, traditional kind. Very few rooms had seating suitable for interactive, small group teaching styles and the four "Drawing Offices" which seat 30 each were heavily used for Design tutorials which required flexible seating arrangements. At a Faculty meeting (November 98) on project based learning, the availability of suitable working and discussion spaces for students working on projects was raised as an issue of serious concern.

Suggestions from the central university administration to relocate parts of the School of Engineering had been strongly resisted, with an overwhelming majority of staff affirming (in an e-mail survey, and at a specially called Faculty meeting) their desire to keep the School together. By the end of 1999, proposals for a new building were taking shape and these gave priority to a location adjoining the current site, with alterations to the existing building.

### 4.4.5 Values and cultural norms manifested by Buildings and facilities

I saw the building and facilities, or more precisely the behaviours, practices and understandings that had developed around them, for both staff and students, as manifesting a range of values and cultural norms. The building played an important role in the lives of students and staff. The physical reality of its separateness and self-contained facilities allowed them to centre their daily practices within it, strengthened their identity as Engineers and marginalised them from the rest of the university campus.

The strong desire to keep Engineering in one building demonstrated that:

- Identity as Engineers and cohesion as a School was strongly valued.

The perception of isolation from the rest of the university reinforced that:

- Engineering saw itself as having a separate identity within the wider university.

The close interactions and self sufficient, identification with the one building contributed to perceptions of "home":

- Building was valued as a familiar place that epitomised "belonging".

Although its role was changing, the 12th floor common room manifested the perception that:

- The concept of an integrated interdisciplinary School was valued.

## 4.5 Art works and memorabilia

The lack of spontaneous comments from any staff or students, coupled with my own observations, led me to conclude that artworks were not a priority in the School of Engineering. Those that were visible could be classified into three groups.

Firstly, there were a large number of visible commemorations of technical achievements and engineering works. These included photographic enlargements of engineering works, such as the progressive construction of a hydroelectric dam, or an oil refinery, and a very recent, high quality colour print of the Des Britten motorbike. Other photographs were of equipment and machinery within the engineering school, and the clothing style and length of hair of the male technicians and students in these pictures dated them as emanating from the late sixties or early seventies.

Secondly, walls of corridors often contained posters originally prepared for conferences, student project presentations, or displays from previous Open Days which commemorated the research, and work done by staff and students.

Thirdly, a series of photographs of "heroes" such as the eight graduates who had become Rhodes scholars and the previous Deans of the School were displayed in the Dean's suite. As a woman, I quickly recognised these as "men in grey suits", but as the Dean of the time said to me when I remarked on the dominant images of masculinity "Well, they were men, what do you expect?". Two large portraits of early Deans of the School had also been displayed for a number of years in the 12th floor common room. Modern heroes such the alumni involved in the 1995 and 2000 America's Cup triumphs, or the current students who have won prestigious design competitions were surprisingly not commemorated, except in a book of newspaper clippings and on a noticeboard in the Common room. My observation, after discussions with other staff members, was that such commemorations would be "a good idea", and their absence was not due to lack of pride, but because no staff member had the responsibility for such projects, and amidst other pressures they did not happen.

The only memorabilia that had been developed by the Engineering Alumni was a traditional necktie with the university crest. There was no Honours Board, commemorating scholastic excellence, and the list of Presidents' of the Engineering Students Society displayed in the foyer was years out of date (last engraved in 1990). Although a book has been written on the history of the school, there were no memorabilia or reminders of a quite unique history on display except for a plaque just inside the front door that commemorated the founding of the School of Engineering in 1923. As one senior staff member commented:

> *There is no sense of institutional pride. No photographs, displays, roll of honour board, list of long serving staff – this building doesn't ooze any collective experience.*
>
> *SStaff1, Oct 97*

In an environment which until recently had an almost exclusively male staff, the norm was for:

- Artworks that focused on creativity and excellence of innovation, in engineering solutions.

Engineering solutions were displayed that not only performed the task they were designed for in an optimal fashion but also had an elusive, indefinable quality of beauty to the Engineering eye.

## 4.6 Dress

Engineering jokes implying that engineers have no dress sense or sense of style abound on websites and as cartoons. For students, the emphasis was on casual practicality, with T shirts or sweat shirts and jeans the most common dress. Trish's comment below, that engineering students and staff were not preoccupied with either high fashion or imaginative dress, was supported by my observations:

> *The dress standard is pretty relaxed, but there are different rules for different people… It's ok to dress up (particularly if you have work – which is more common than just a few years ago) …The usual dress code for engineers is jeans or tracksuit pants, shorts and T shirts. Skirts are also fine. It depends a lot on the personality of the wearer… it wouldn't be something that lots of engineers would comment on*
>
> *Trish, 4th year Civil 1997*

In the early 1990s I had observed that almost all of the female students wore trousers and loose clothing, with the odd student who wore a skirt always commented on and highly visible. This had markedly changed, and by the late 1990s, although jeans or their equivalent were still the norm for female students, skirts, sunfrocks in the summer, and even shorts and singlet tops were worn without apparent unwelcome attention or comment. This diversity of apparel was probably due to a number of factors, including fashion changes and increased ethnic diversity, but I believed it had been assisted by the lessening of individual visibility brought about by the increased numbers of female students.

Gendered identities are often conveyed by visual images, physical features, hair and particularly dress. The majority of male and female students wore clothing of a similar nature, but for female students clothing offered the potential for more overt statements of their gendered identity i.e. their femininity. Although the majority of female students were clearly most concerned with practicality and comfort in their choice of clothing, it was evident that dress provided the opportunity to send visual messages either intentionally or unintentionally.

Trish (4th year Civil, 1997) also commented that it was "not OK to look sexy". She explained that this was "not accentuating the feminine" rather than dressing like a man. However, "looking sexy" was not always intentional. In a setting where 80% of students were young males and as one staff member had commented "the testosterone is at its peak" (Diary1, June 1996), the awareness of potential sexuality was not far beneath the surface and the easy camaraderie female students usually enjoyed sometimes received a jolt. For example, a female student was shocked at receiving an unwanted, very explicit sexual invitation when she wore a sunfrock to class (Diary3, 16 March 1998). Perhaps the most revealing commentary on this incident was that the student took no action against the young man other than telling him to "get lost". My concern on hearing of this incident was for the possible effect should the male student continue this behaviour without any awareness of its effect on a less confident female student. I also wondered if the female student ever wore that sunfrock to class again.

Several male, usually older, staff discussed with me their discomfort when female students wore fashionable clinging, low-cut tops – a discomfort arising from being jolted into an awareness that these were young, often physically attractive women rather than just another student: "we're only human after all and it can be downright embarrassing especially when they lean over your desk" (Sstaff5, Oct 97).

For male students, dress and appearance involved little choice other than "how formal" and dress was not perceived as demonstrations of "masculinity". Although rarely voiced, female students appeared to be aware of wearing "appropriate clothing", where appropriate was likely to mean clothing which was practical and did not distract from their role as engineering students:

> *When I am here, I have one persona, when I am at home or with my friends it is quite another – sort of voice seems to be deeper than normal – goes higher in pitch at home? It is like, here I gotta wear the jeans and at home I gotta wear the breezy, revealing clothing especially in summer.* *Julie, 4th year Mech, email, 2/10/97*

> *We don't see any engineering girls coming in wearing their skirts or… I wear skirts sometimes, but climbing over the desks in the lecture room …like if you want to get out of class quickly….and the stairs here are really bad, they are all gappy stairs – like in the library and you walk up the stairs and you think "Oh why did I have to wear this today…"* *Jaya, 1st year student 1998*

Students recognised appropriate occasions for more formal wear, such as scholarship interviews, where smart casual wear was the norm, and for final year project presentations to which industry was invited. For male students, a suit or at least a shirt and tie was usual on these occasions. Both students and staff appreciated these opportunities for "dressing up" and it was with pride that staff commented on how well the students "scrub up"

> *You must remember our students scrub up well, the guys and girls do look good don't they.* *HOD1, Jan 1998*

For female students, however, these more formal occasions often presented a dilemma. Firstly, they had to choose between a skirt or trousers. Secondly, on student budgets, with few occasions for formal wear, they often had limited choices. I was often asked the questions "what should I wear, a skirt or dressy trousers" or "if a short skirt is all I own, is that OK?". They wanted to look professional and fitting the role of "Engineer"- which they perceived as requiring them to play down their femininity, so that it did not intrude on the situation in hand. Rarely was makeup or jewellery worn at such times.

The majority of older staff were conservative in their dress, with casual wear in the holidays, but a shirt and tie more common when the semester and student contact via lectures started. A predominantly younger group of staff were more casual in their dress, with open necked shirts and collared knit shirts their normal dress. Jeans were not uncommon with this group of staff. Staff recognised that dress could be used to differentiate them from students and assert authority.

> *I shall wear a tie come Monday. For me it is normal, but not for the School. I am happy to be on very good terms with students but it doesn't help them to pretend to be equals*
> *Sstaff1, Oct 97*

> *I usually wear a shirt and tie when lecturing – helps maintain an air of authority. I noticed R… starting wearing shirt and tie when he had some discipline problems*
> *Jstaff1, Jan 98*

The few female staff made individual decisions on appropriate levels of formality – no female academic staff were seen in the equivalent of a formal business suit, but casual clothes, usually trousers, were worn. In each case femininity was not overly accentuated by clothing, jewellery or the wearing of makeup, although individual style was still evident.

The one occasion when both male and female students really allowed their gendered identities to be given full expression in terms of dress was the Engineering Ball, a formal, dress-up occasion with all arrayed in their finest. Female students often wore fashionably revealing, figure hugging outfits which I saw as proclaiming "Yes, I am a woman!".

### 4.6.1 The Engineering T shirt

In contrast to other faculties and departments on campus, I observed the prevalence of T-shirts or similar items of clothing that identified students as engineers. A T shirt was created for everything, often with costs subsidised by the Engineering Student Society – pub crawl participation, Round-the-Bays Run participation, membership of the Engineering Student Society, the Women in Engineering Network, separate engineering departments…

Several T shirts epitomised values and attitudes that students might have in relation to their engineering education. One of the most memorable, and repeated over several years with minor variations, was the 'Super E' T shirt pictured below (Figure 4.5). Modelled on the Superman logo, in the same colours, the Big S was replaced by a big E. It seemed to me to reflect the pride, superiority and sense of belonging that engineering students had. This T shirt was worn any day or any time, but particularly when groups of students wished to be identified as engineers, such as when they visited a school, or had an organised water fight against the business students.


Fig 4.5 The Super E T shirt

In recent years, the "clever" adaptation of company logos such as that for Steinlager beer, or Lotto (became blotto), had been favoured. In 2000, America's Cup year, the School T shirt was a collared, short sleeved shirt that was a very close imitation of the expensive Team NZ shirts, with each sponsor's name humorously amended. These "clever" T shirts, relying often on double meanings, puns, and in-house humour had gradually replaced the more offensive T shirts of previous years.

The "bloke" or "lad" element within the student body seemed to surge to the fore from time to time, with particularly offensive graphics. My diary (2.5.97) recorded comments such as: "I feel sick – I have just walked through the foyer and the pub crawl T shirts are there", when an anatomically correct cartoon version of a male "backside" adorned the back of a T shirt, signifying an engineers' disrespect for other students on the pub crawl. Apparently two versions were being sold, but my response as a woman, and as the staff member with responsibility for equal educational opportunity, was "I am absolutely appalled at anybody thinking that is funny. I am also appalled that some young women are wearing it… if that is how they really think – what the hell am I doing here" (Diary, 7 May 97). That T shirt was rarely visible after that morning as other staff and students made their opinions known – this was NOT the image they wanted displayed of engineering out in the community. Female students felt strongly enough and (strong enough) to launch a petition about it:

> *I was impressed earlier this year with the petition they sent round about the T shirt and I remember being in the lecture room when the sheet was passed around and I went and had a look at it. I was really impressed with that… It was supported by men as well. I had to say I found the T shirt really offensive and I was really pleased that they had started the petition, and with the discussion as well* *JStaff2, Oct 97*

Notable in the late 1990s, when I carried out this case study, was a lack of approval and condoning of behaviour which might in previous years have been viewed as "Boys will be boys". In this regard I had also recorded in my field notes:

> *At Faculty meeting today, I was pleasurably surprised when XX, (an ex HOD, and well respected member of staff) unexpectedly stood up and berated the student representatives commenting that "I would just like to say that the recent T shirt and little magazine were of such a low level I was most unimpressed with the lack of professional attitude and I thought things had begun to improve". It is reassuring that my feelings are shared by other staff especially the males.* *Diary, 7 May 199*

Another male staff member commented in an interview:

> *We have had a few T shirts which annoyed me I mean some of the T shirts aren't the best, I don't think that is right, women or non women, I just don't think that is right. …heard a few days later that (Assoc Dean) got on to him, and said stay away if he wanted to wear the T shirt.* *JStaff1, Jan 98*

The female students in their undergraduate student group, WEN (Women in Engineering Network) were also keen to promote an annual T shirt. Their understandings of what was acceptable, what would be popular, and their role as women engineers, exemplified in the designs they chose, seemed to send messages of their desire to be considered as women whilst recognising that as engineers they were different or “other” than the norm.

Three of these designs provide examples of these understandings of “femininity”. The first displayed their commitment to engineering, with a cartoon on the back of the shirt displaying a picture of two young women drinking coffee, with bubble comment: “*Well, he said I had to choose between him and engineering. Pity, I really liked him.”*

The second, had Six Reasons to date a woman engineer such as:

- We can handle our fluids
- We know how to handle stress and strain in our relationships
- We can deal with time delays, reluctance, resistance, density, errors and the occasional catastrophic failure…

The third, which was extremely popular, particularly with students of non European backgrounds (and had been repeated over two years) was a fitted T shirt catering for smaller sizes, with the cartoon of Little Miss Engineer (Figure 4.6).

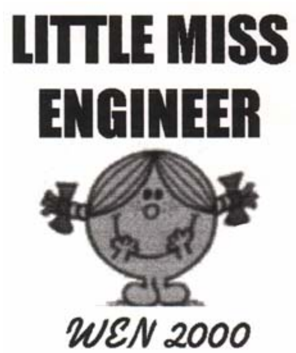


Figure 4.6  Logo from WEN T shirt 2000

It was unclear to me why this design was so popular. When I queried its appropriateness the students assured me that they saw this image as a joke, a “take off” of who they believed they were i.e. strong, confident young women. I inferred that female students clearly desired to be recognised with pride as engineers, but also as women.

While the Engineering school did not put students into a uniform, the T shirt provided homogeneity within the group, a sense of "uniformity amongst diversity". The Engineering T shirts with their logos and graphics provided strong images, and an implied sense of belonging which seemed to carry with it a status, identity and loyalty to Engineering.

### 4.6.2 Cultural norms manifested by Dress

The visual manifestation of culture in the form of dress provided information about cultural norms, which I have interpreted as:

- Practicality took priority over style in dress for Engineering students and staff.
- Dressing more formally was recognised as a signal of professionalism and authority.
- Vulgarity and obscenity on clothing was not condoned.
- The prevalence of T shirts with engineering logos symbolised the students' sense of "belonging" and "engineering identity".
- Female students sometimes used clothing as a symbol to demonstrate their wish to be recognised as women despite studying engineering.

## 4.7 Composition and characteristics of student and staff

Because gender and ethnicity are visible whenever a group is gathered together and also available from statistics, I have included a discussion of homogeneity (or lack of it) in this chapter on artefacts. Socio-economic or class differences could be expected to be more subtle. However, because similar educational backgrounds and life experiences would be likely to lead to shared personal values and beliefs I saw an examination of the homogeneity or diversity of the staff and student bodies as integral to understanding the context of the case study.

At the time of the study the undergraduate engineering degree was in high demand, with approximately twice as many applications as met the selection criteria. Artefacts such as handbooks and online information described current selection practices. The primary requirement for a student seeking entry to the BE degree at the University of

Auckland after 1998 was an academic record equivalent to an A Bursary (300 marks) in the NZ University Entrance Bursary Examinations. This was equivalent to the highest entry level of any Australian university for engineering degrees. The selection criteria (practices rather than artefacts) resulted in the degree having a perceived higher status than the open entry degrees such as science and arts, with students recognising that a characteristic of their classmates was that they were all able students. This led to behaviours which included a sense of pride in being accepted into engineering:

> *When I came to engineering I found it an intense step in terms of work ethic, and the general buzz, the intelligence, because it is harder to get into, you have to have certain marks* *Angus, 1st year 1998*

Prior to 1998, students had chosen their engineering discipline on application to the first year, and since each discipline had a limited number of places, a hierarchy of disciplines had developed. The published statements that Electrical Engineering required an entry level significantly higher than other disciplines such as Chemical and Civil Engineering had the result that when I was advising students, I often observed them choosing their discipline based on perceived “status”, rather than knowledge, interest or ability. Another perception was that the range of entry qualifications implied an elitism or level of difficulty for some disciplines and lower academic standards for other disciplines. The final year graduating students interviewed for this research had entered under these entry requirements, where Electrical engineering students had been selected at a much higher level than those in other disciplines and my interviews, particularly with several of the women students, verified my perceptions:

> *I applied for electrical because it was the hardest to get into and I thought I’ll go for electrical so that when I finally decide what I want to do I can change*
> *Heather, 4th year E&E 1996*

The demand for the BE degree, coupled with a reduction of funding allocations, led to a change in selection policy in 1998, when quotas at entry level were dropped and all students who met the entry criteria were accepted. The aim was “to accept all students who had a reasonable chance of success” (Assoc Dean, Jan 1998). This resulted in a large increase in applications and qualified entrants, confirming the strong demand for the Auckland BE degree. Table 4.1 demonstrates the resultant “leap” in student numbers at Part I in 1998 and its flow on to total undergraduate students.

Table 4.1 Statistics for new entrants and total undergraduates 1996-2000

| | **1996** | **1997** | **1998** | **1999** | **2000** |
|---|---|---|---|---|---|
| New to Part 1 | 225 | 273 | 421 | 414 | 415 |
| Total Undergraduate | 1263 | 1252 | 1334 | 1446 | 1562 |

Also published, and indeed highlighted in handbooks and online, was the requirement that all applicants to courses in Engineering (with and without credit) must have achieved an examined standard of competence in English (higher than the standard university entrance level). This was a visible confirmation of the need for competency in communication to successfully take part in the wide-ranging communication skills components of the course, both written and oral, and participation in group-based activities.

### 4.7.1 A diverse student population

Contrary to the situation in the 1970s and 1980s when many of the staff had been students, the majority of the student body was not white and male, and at any large gathering of engineering students the diversity of races was immediately evident.

> *The first days – Big number of people… …the mish mash of different faces …first year has people from all different origins, very diverse– that was really interesting – that was the most noticeable, the number and the diversity* *Angus, First year,Oct 98*

Statistics provided in 2000 by the University of Auckland (see Figure 4.7) showed that the student body in engineering had the highest proportion of non-New Zealand born students of any faculty on the Auckland campus, the majority of whom were from South East Asia. These students were permanent residents or New Zealand citizens rather than international fee-paying students and the majority of them had been partly or completely educated at New Zealand secondary schools.

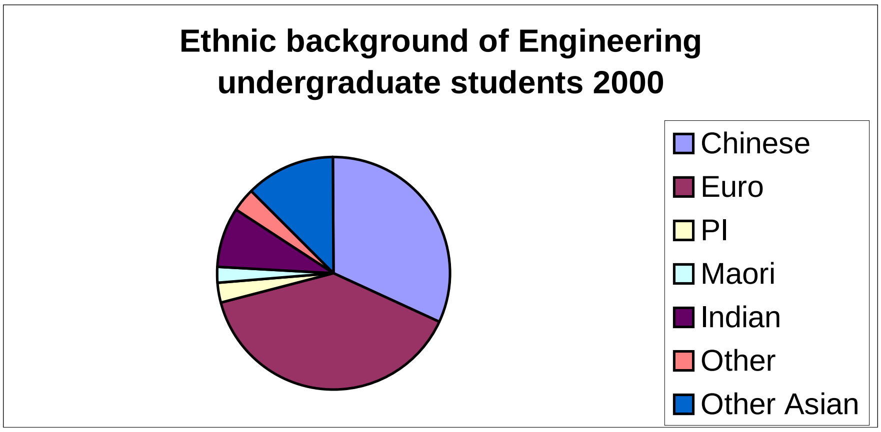


Figure 4.7 Ethnic background of Engineering undergraduate students in 2000

The School of Engineering had a stated policy of Equal Educational Opportunity.

> *The School of Engineering is committed to attracting and educating students with the potential to excel in their studies and within the profession, regardless of ethnicity, gender, disability or socio-economic background. The under representation of some groups such as women of all backgrounds, and students of Maori and Polynesian descent is of concern* *IPENZ Accreditation Review documents 1995*

This concern with underrepresented groups had resulted in a number of initiatives by the School including one to fund a lecturer with specific responsibility for recruitment, retention and curriculum initiatives to encourage higher participation by Maori and Pacific Island students.

The support and commitment of the School, discussed earlier, to increased participation by women, was reflected in an overall participation rate by 2000 at undergraduate level of 20.8% (See Figure 4.8). However, quite major differences in female participation by sub-discipline were persistent. In 2000, for example, female participation by sub-discipline was: Engineering Science 45.5%, Resource 41.5%, Chemical and Materials 38.5%, Civil 20.5%, Software 19.4%, Electrical and Electronic 14.2%, Computer Systems 13.8% and Mechanical 11.1%.

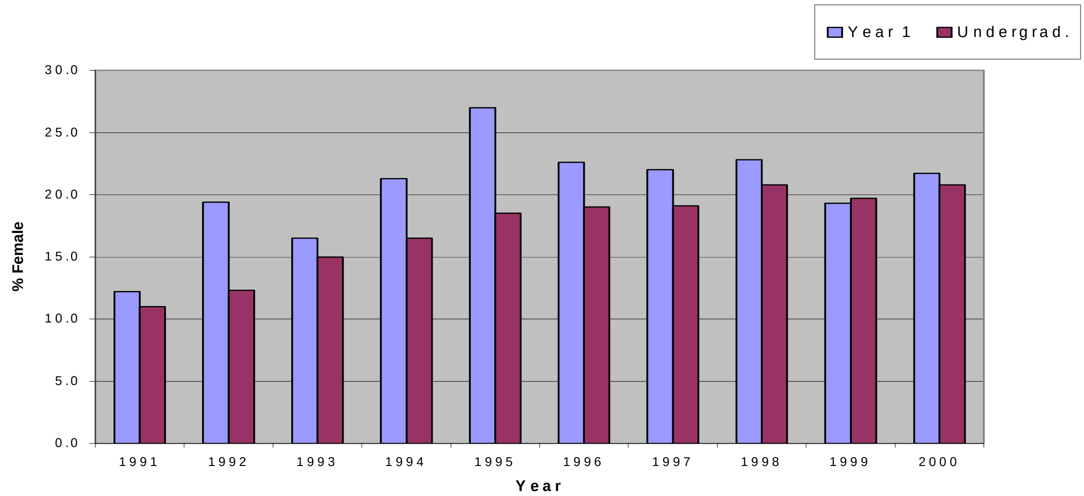


Figure 4.8 Women's participation in engineering at the University of Auckland

### 4.7.2 Staff characteristics

Records showed a rapid growth of staff in the 1970s and early 1980s and quite a large number of these staff (all male) were still teaching in the late 1990s (35 of the current 100 staff). These were the staff who held the memory of traditional practices and behaviours and currently, as senior academics, had the power and authority to maintain cultural values and norms. A substantial group of these older staff, particularly in some disciplines like Civil Engineering did not have PhDs and had been hired on the basis of professional experience. By the late 1990s, university and faculty policy was for new academic staff to all have PhDs, with a resultant dilution of staff with solely professional engineering experience.

The high proportion of the staff, including the current Dean, who were themselves graduates of the U of A appeared likely to have influenced the maintenance of a stable set of cultural values and norms. This stability was, however, potentially fragile, as academic staff hired in the 1990s were increasingly overseas trained, coming from very diverse academic and ethnic backgrounds, and therefore bringing with them the likelihood of diverse personal values and experience.

### 4.7.3 Cultural Norms manifested in the characteristics of the staff and student bodies

The following cultural norms were manifested by the statistics and procedures discussed in the previous section:

- Students viewed themselves, collectively, as academically superior.
- The student population, of whom nearly half were not born in New Zealand was ethnically diverse.
- Female participation and retention was relatively high.
- Male staff were in the majority, a significant proportion of whom were long term and ex students.

## 4.8 Summary

I acknowledge that a visitor observing and interpreting artefacts would rarely acquire a full picture of a culture's values and norms, but clues can be gained from related behaviours and practices. I have interpreted shared values and norms from the practices and behaviours associated with the artefacts at the end of each section in this chapter. A detailed tabulation of these values and norms, the second level of my analysis, cross referenced to the sections in this chapter which evidenced their manifestation, is provided as Appendix 13.

In this chapter I have, for example, shown how a single building of concrete and glass, combined with behaviours and practices around its usage, has become a symbol for a strong sense of identity, belonging and interdepartmental co-operation. The sense of identity and belonging as "Engineers" appears to have been enhanced also from the norms arising from publications and dress. The norm of numerically dominant male participation was shown to be observable and confirmed by statistical evidence, but I have also highlighted the ways in which the institution made explicit its commitment to increased female participation (such as the gender inclusive imagery in faculty publications). The highly visible ethnic diversity at student level, and the increasing participation of women, might well have appeared at odds for a newcomer to the dominant images conveyed by student publications, which were still those of the traditional, male, alcohol-oriented engineering student.

Building on this discussion of Artefacts, I now proceed to the next chapter in which I discuss Practices, the second sub-level, on my analysis model, of observable and tangible cultural manifestations.

# Chapter 5

# Practices

## 5.1 Purpose and outline of chapter

In this chapter, my purpose is to look at the second sub-level of my analysis in answer to my first and second research questions. I explore in-depth examples of the day-to-day practices, or as suggested in Chapter 3 “how we do things round here”. During data collection I identified many practices. Some I saw as contributing to my research questions, i.e. providing an understanding of what was cultural – demonstrating shared values and cultural norms. Others were better described as phenomena – experienced by almost any group of people studying and working alongside one another. My analysis does not therefore highlight every teaching technique, event, or type of assessment, but focuses on those which I have identified as providing a representative picture of practices relevant to this case study.

As in Chapter 4, I provide evidence to support my observations and interpretation of these practices as culturally significant from verbatim reporting of participants’ comments and, where appropriate, written documentation.

The practices reported in this chapter contribute to my interpretation of cultural norms and values that will be used to answer RQ1. The sections on pedagogy and assessment, in particular, provide detailed examples and evidence from the first year of the course to answer RQ2, by forefronting the enculturation processes by which I suggest students were led into shared knowledge and understandings of the engineering education culture. Following the pattern in Chapter 4, I also interweave a consideration of the interaction of these practices with gender to answer the second part of both RQ1 and RQ2.

I begin the chapter with an in-depth analysis of the practices of pedagogy and assessment, followed by an examination of reward systems and regularly occurring events. I then include a discussion on the nature of interactions with the profession and other faculties on campus. Finally, I bring together, as the second level of my cultural analysis, the values and norms that I have identified as manifested in the practices discussed in this chapter.

## 5.2 Pedagogy

Pedagogy can be defined as the principles and practice of teaching. In this section I examine the manifest practices by which teaching occurred in the case study institution, using the words of staff and students as evidence of the shared understandings around those practices.

### 5.2.1 Current practice

The standard full time load for students was a total of 14 points of study per year, seven in each semester. Each point required two and a half hours of scheduled participation per week, with an additional six hours per course for those courses with a substantial laboratory component. Departmental timetables showed a maximum student contact time per week of 20 hours. The student handbook identified "that students are expected to commit their own time in a ratio of 1:1 to the timetabled contact hours" implying an expectation that students would commit at least 40 hours per week to their study.

Class sizes varied. At Part 1 level, there were two streams of over 220 students, but once students moved into their discipline specific courses the class sizes ranged from 100 to 150 in the Electrical and Electronic department to less than 40 in the Chemical and Materials, and Engineering Science departments. When all students came together for the core courses of Mathematical Modelling and Professional Development, class sizes were between 300 and 400. Tutorials and design classes were usually thirty or less, to ensure close interaction and more personal contact than the lecture situation provided.

The U of A saw itself as a research-led university and the School of Engineering claimed proudly that "*Our research vigour continues to grow, with our academics having strong international links, and some research programs being world leaders in their areas*" (Vol 1, p.6, IPENZ Review documents 2000). The links with research were manifested to the students in the practice that even the most eminent international researchers taught undergraduate classes.

### 5.2.2 The restructured BE structure

The opportunity provided by a university-wide move to a semester system, with common point values for papers[1] resulted in the restructured BE degree introduced in 1996. In July 1994, the Course Revision Committee reported that:

- *Our students are frequently unmotivated and bored by their course*
- *Our students have very heavy workloads*
- *Our courses and assessment methods do not emphasise understanding and application, but tend to focus on the acquisition of large volumes of engineering knowledge and analytical skills*
- *Our students view their current course as very compartmentalised*

> *The first year of the BE course is not focused on engineering and our students do not feel that they are engineers.*
>
> *Paper presented to Faculty meeting, July 1994*

The Course Revision Committee took account of recent international reviews, referred to in Chapter 2, which called for Engineering Education to widen the traditional curriculum to include communication skills, environmental management, economics and international relations. Staff believed that the restructured Auckland degree was aligned with that call:

> *…the IEAust Review came out soon after we started, and I felt we could have written it, our new degree matched what they wanted done – so our thinking was really up there with current engineering educational thinking.* *Faculty meeting, 18/11/98*

The restructured degree was still a four year professionally accredited Honours degree but the first year went from an “Intermediate” format of basic science courses to a common first year of engineering courses. Students chose their discipline at the end of this first year and from Parts II to IV studied a discipline-specific compulsory curriculum. In general, the only choice of papers occurred at fourth year level, and usually these “electives” were from within their own discipline.

With the aid of the new structure, curriculum changes were made to address the issues raised above by:

[1] Prior to 2000, the term “paper” was used for an individual course or assessable unit within the degree.

1. Bringing first year students straight into in-house engineering related subjects. Statistical evidence suggested that engineering students who successfully carried on to second year of engineering found the general, science based first year repetitive of schoolwork. There was a strong desire to move students straight into the engineering way of thinking:

   *We moved away from intermediate plus three professional years, first to the common first year in 1991, which was a lot of science but some more engineering and now to engineering right at the beginning of Year 1. I think that has been an excellent change myself – I think when people came through Intermediate it gave them a scientific way of looking at things right from the beginning which wasn't what we wanted.*
   *Dean2, Feb 1997*

2. Reducing the number of formal lecture hours.

   One goal of the new degree structure was to reduce teaching contact hours to ensure more opportunities for self directed learning and project based learning. The high value placed on what was viewed as the essential body of knowledge in the discipline appeared to make this reduction in teaching hours problematic:

   *Everybody feels that his particular academic area is fundamental to the core of engineering and will not cut anything out of it at all, they tend in fact to pile more knowledge in as more knowledge comes – SStaff3, Sept 2000*

   *The new degree meant we were trying to compress lecture content into less lectures – you can't reduce the content. You need it to be comparable with overseas universities like Australia, UK and Asia. (lecturer C&M) – Diary 7, 23/10/98*

   Even the students appeared to have assimilated the idea that reduction of the content was difficult:

   *I feel there is so much to learn in engineering – what can they replace, there is so much information to pass onto the students, what could you leave out, if you replace one of the parts they would lose out on the information in that paper. Mei, 4th year E&E, 1996*

3. Relating theory wherever possible to relevant, engineering applications to raise interest and motivation:

   *…we needed to really grab their attention in that first year, that this is engineering – show them why we learn stuff and where we use it HOD1, Jan 1998*

4. Increasing the proportion of problem or project based teaching:

   *We thought there was too much drudgery in formal stuff and thought that more effective, better learning was achieved when the students worked on projects. Our experience in some design projects and final year projects was very positive and we thought that getting more of that sort of learning was desirable SStaff2, Jan1998*

5. Introducing a core of Professional Development courses:

   *…major change was to recognise that there did need to be a stream of things throughout the course which was not just technical based, but had management and that built in, including communication skills and understanding of society in general.*
   *Dean2, Sept 1997*

Staff saw these changes as an attempt to shift more responsibility for their learning to the students themselves:

> *The repackaging of our subjects into only seven papers per year has been a pretty tough test…. Well I think there has been a reduction of content, but with the extra bit we have done in Year 1 we have actually managed to do some pretty interesting things…if we can get the students learning for themselves we have got a major plus. So that is what we are working on.* *HOD1, Jan 1998*

There were limitations on how much the curriculum could alter. A major constraint in curriculum design was the need to provide the "in-depth core of scientific and technical skills" required to meet internationally accepted and moderated standards laid down in the IPENZ "Requirements for Initial Academic Education for Professional Engineers" (which are included in this dissertation as Appendix 11). As a consequence of the required "coherent body of knowledge related to a particular branch of engineering", each degree program contained a high proportion of engineering science courses such as Fluid Mechanics and Thermodynamics and course structures were almost inflexible. Students were unable to avoid courses that they found uninteresting or difficult:

> *In Year2 and 3 papers were compulsory so you have to do work that doesn't suit*
> *Questionnaire F2, 1997*
> *I have really disliked how inflexible the course was. How little opportunity I had to make it what I wanted* *Richard, 4th year E&E, 1997*

### 5.2.3 The common first year program

Since 1996, the common first year program was as follows:

| | | | |
|---|---|---|---|
| Materials Science | (2pts) | Engineering Design 1 | (2pts) |
| Engineering Mechanics | (2pts) | Mathematical Modelling 1 | (2pts) |
| Engineering Computing | (1 pt) | Environmental Principles | (1 pt) |
| Electrical Engineering Systems | (2pts) | Self chosen elective | (2pts) |

This first year program had been developed to meet the following goals

- *To develop – fundamental engineering problem solving skills,*
  *a logical and lateral approach to problem solving and design,*
  *the ability to use computers as design and analysis tools,*
  *the ability to design and construct useful experiments,*
  *the ability to use mathematics to describe and analyse a physical problem (including the ability to sketch, approximate and estimate),*
  *the ability to communicate engineering concepts to others by written and oral means, and*
  *the ability to work effectively in groups.*

- *To reinforce the problem-solving skills with design projects that attack 'real' industrial problems*
- *To introduce all students to the various engineering disciplines and their interaction with society*

*(IPENZ Accreditation documentation 1995)*

An evaluation conducted by the University's Continuing Professional Development unit at the end of the first year of the new course (1996) revealed that there was almost universal agreement from participating students that the program helped their understanding of the engineering profession.

As I noted earlier (5.2.2), one of the aims of the in-house teaching of the common Part 1 papers was to introduce first year students into the engineering "way of thinking". Comments from the 1998 first year students confirmed the achievement of this aim:

> *Diverse range of courses – not one overriding philosophy. Some courses seem to be teaching us to think as engineers whereas others, rightly so, are concerned with basic knowledge, the calculations, the details* *Laurie, 1st year student 1998*

> *…thinking like an engineer, kind of being taught it I suppose. The whole course is directed at making you think differently, that is how I feel it.*
> *John, 1st year student 1998*

### 5.2.4 Common core

A core of Mathematical Modelling and Professional Development papers was common across all disciplines in Parts II, III and IV. The Professional Development core papers responded to the call from professional engineering bodies for all engineers to have an awareness and understanding of "*the social, cultural, global and environmental responsibilities of the professional engineer and the need for sustainable development*" (IEAust, 1996) and "*the issues of professional responsibility, social and environment effects and ethical aspects of engineering practice*" (IPENZ, Appendix 11).

Professional Development papers were a long standing tradition. Prior to the restructuring of the degree the School of Engineering had offered two papers known as General Studies I and II for almost thirty years:

> *A tradition was established of offering a wider outlook to the students than the purely technical. This was pretty unique in those days* *Assoc Dean, Oct 97*

Final year students that I interviewed and surveyed in 1996 and 1997 had all participated in the General Studies program which covered a range of professional and social responsibility issues, and often used lecturers and tutors from outside the engineering school. Student opinion on this program appeared to be polarised: those who enjoyed the opportunity to think outside the purely technical (*"Good to understand something outside engineering" QuM1, "chance to broaden my knowledge" QuM11, "got engineers thinking responsibly about global issues" QuM22 "thought provoking but highlights the narrowness of many engineers" QuM10*), and those who did not *("boring and useless" – QuF10*).

These comments confirmed that many students recognised the need for engineers to think wider than the purely technical, but other comments demonstrated that they wanted information presented in an engineering context:

> *GS comes under a lot of flak. I think they are pointless, should be completely revamped… It would be more useful probably done in such a way as to make it interesting or more relevant – like having someone from engineering who can say ethics in engineering is like this, not just some theoretical thing the philosophy department talks to you about* *Brett, 4th year E&E student, 1997*

As part of the restructuring of the curriculum, the General Studies courses were expanded and, from 1996, the new courses of "Human Social and Cultural Development" in Part 2, "Engineering Management" in Part 3 and "Professional and Community Issues" in Part 4 were phased in. The content of these papers was informed by the IEAust 1996 Review and an Advisory board of IPENZ members, with the result that students appeared to be more accepting of the connection between these courses and their future role as professional engineers:

> *I think engineers need this stuff – they need to be able to look at the bigger picture, emotions, costs, whatever else is there and just – sort of moves into things I think engineering is lacking.* *Richard, 4th year E&E student, 1997*

To ensure that all students had an awareness of the sustainability and environmental issues that face the profession of engineering, the paper Environmental Principles was taught as part of the common Part 1 program:

> *But courses like EP everything you learn is needed when you are later going to be applying for resource consents or whatever, so that was good.* *Laurie, 1st year 1998*

> *That paper blew everyone's awareness open about what is happening in the world and what our responsibilities are going to be, because we know we are entering into a critical time when sustainability is going to be key, the most important thing.*
> *Angus, 1st year 1998*

Social and environmental issues were perceived as marginalised in the Professional Development core papers, rather than integrated into the technical papers:

> *I think they tended to fragment the information about environmental stuff… Maybe they should have it integrated into all the papers if you really value it… What they are saying in their values is that this stuff is not an important part in engineering – it is an aside that we throw in because we have to, but it is not a core part of engineering…*
> *Trish, new graduate Civil, feedback, April 2001*

> *Even when you're doing papers like Environmental Fluid Mechanics it is all in the mathematical perspective but you really have to take in to account other things as well like ethical issues. Papers like OR they talk about minimising and maximising things but you have to take into account business things like economics, accounting and they don't do that in the papers they leave it to General Studies* *Amanda, 4th year Eng Sci, 1996*

Mathematical Modelling formed one of the core themes running through the University of Auckland's undergraduate engineering degree with all students taking at least one paper a year for three years. In the redesigned BE degree basic mathematics courses were taught in-house with a conscious effort to emphasise the development of skills in model building, in contrast with traditional introductory undergraduate engineering courses in mathematics which placed primary emphasis on mathematical skills:

> *What struck me is that maths is a tool. It is not the maths that is important, but the stuff that goes with it, applying it to a problem* *Brian, 1st year 1998*

### 5.2.5 Theory linked to real life applications

Staff responded to the goal of including engineering applications by teaching theoretical concepts in real life contexts wherever possible:

> *Because it is engineering not science, we spend time talking about application areas, but much of the time the responsibility is to get to the underlying science. If we only do that, wouldn't have an engineering degree, so then we have to try and instil in them the ability to take that science and apply it to the unknown* *SStaff6, Sept 00*

> *Those courses are about developing mathematical tools that get used in other courses, so we can draw on applications from all sorts of different areas, but I certainly try and draw in practical examples, it does help, the students aren't good at absorbing completely abstract material* *JStaff1, Jan 1998*

Students did not enjoy very theoretical and technically focused lectures "I hate learning things when I can see no practical application" (QuM27) and there was obviously a desire to know "why these concepts are important and how they are used in engineering practice" (QuF14). The need to be able to visualise the technology and terms being used is likely to be common to all students. Female students made particular reference to their frustration when this need was not met:

> *…Or the geotech lecturer being stunned that Susan had never seen a geotechnical report (but neither had 90% of the class) or when we discuss or design "piles" – most of us have never seen one – I certainly never have. They assume you know what one is. You feel so dumb and so frustrated!!! They should get videos or pictures.*
> *Trish, 3rd year Civil, 1997*

> *I felt that Dynamics and Control was all theory, like I couldn't understand where or how all these sort of actuators and PI controllers – you know I couldn't picture them actually working in a factory or anything.* *Chloe, 4th year Mech, 1996*

First year students were very enthusiastic about the way the "real world" applications were incorporated into their lectures:

> *…there was this American guy who talked really excitingly about turbines and metals and talked about the Liberty ships made out of metal that weren't able to sustain the extreme cold and what happened when they used those Liberty ships in the north Atlantic. I got really excited by those excerpts of real life brought into the lectures – I remember rushing home to tell my Mum – she's a science teacher…*
> *Brian, 1st year, 1998*

I found it difficult to ascertain the extent to which prior understanding connected some students and left others with a feeling of inadequacy. Although a subject like first year Mechanics used examples, such as gear wheels, wrenches, cranes etc, these were not necessarily in the "real life" experience of all the students, especially as almost all of the current students came from highly academic backgrounds:

> *I didn't think there would be so many theory based people who have very little practical knowledge of anything.* *Josh, 1st year, 1998*

In my discussions with female students it appeared that many of them saw themselves as lacking experience across a range of subjects as demonstrated by the following comment:

> *DECS – in second year that was the one I didn't like, it was my worst mark ever. I think it was because it was all these new things I had never heard of and they were just thrown at us and taken for granted you should have heard of it before you came into the School of Electrical Engineering… I think the guys – well sometimes they get to know a lot more about little things than the girls do … little things like computer architecture and hardware and lots of little things like that… I think the girls aren't quite as familiar with those sort of things.* *Miriam, 4th year E&E 1996*

There was clearly a difficulty in "real life applications" if some students had no background experience or knowledge. As Miriam carried on to say:

> *I think it is because they have been in the discipline so long, they can't imagine you not knowing what an amplifier is if you are doing an electrical engineering course – I guess it is a fair assumption that 99% of the people would know*
> *Miriam, 4th year E&E, 1996*

Female students were not the only ones disadvantaged when assumptions were made about prior knowledge but, in contrast to the majority of the male students interviewed, no female spoke of her interest in engineering being aroused by hobbies or experience such as building models, dismantling appliances, or a holiday job on a building site. The incorporation of "real life applications" was valued by all students. I saw it as essential that care was taken with prior assumptions about the nature of "real life" experiences.

### 5.2.6 Role of mathematics

> *You know you are an engineer if you haven't got a life and can prove it mathematically*
> *Diary, 27/1/99*

This joke, made by a second year student at an orientation for first year students, epitomised for me the all-pervading role that mathematics played in the study of engineering.

Mathematics was seen by both staff and students as the key to access, understanding and thinking as an engineer:

> *Engineers – well they quantify things, they put everything into numbers, can't just be descriptive… JStaff2, Diary8, 9/6/00*

After one year at the engineering school students identified that to be an engineer was:

> *Engineers have to be able to, have a mathematical mind, and enjoy maths I guess or at least tolerate it. I think it is the most important thing Alex, 1st year, 1998*
>
> *As far as an engineering "way of doing things" goes, a facetious response would be "so they get done", or possibly "using maths". However such comments are actually pretty close to the mark – most people I've dealt with believe in the application of humour and plenty of suitable mathematics Laurie, 1st year, 1998*

For some lecturers and students mathematics was valued for its beauty:

> *The beauty of mathematical developments is wasted on some but some will marvel at the mathematical development of theory and understand and these are the ones who may well go into advanced research… When you feed the garden and give substances rich in minerals, plants might take up different minerals and what suits one might not suit another. SStaff6, Sept 2000*
>
> *"…the beautiful mathematical equations are better than sex"*
> *"I love learning about the beauty and potential of maths"*
> *quotes from first year engineering students in 'The Alternative Calendar, 1999*

However, it was more common to hear mathematics spoken of as a "tool":

*The concept of the aesthetic beauty of a theory is remarkably absent in engineering. This is unlike pure maths where time and practicality are not relevant. Here the emphasis is on power and utility not truth and beauty.* *JStaff6, Sept 2000*

*…I like the fact that at Engineering School you study things like differential equations for a reason, and relate them to something real* *Rose, Eng Sci graduate, 1997*

It was not uncommon to see lecture notes and blackboards completely taken up with mathematical formulae and computations, and in section 6.4 I say more about the role of mathematics as the language of engineering, used as a means of communication by members of the group.

I found that mathematical skills and techniques appeared to be applied in three ways within engineering: the application of existing formulae, the derivation and development of theory, and to model complex systems.

In the first instance, the majority of engineering courses, particularly those which were seen as technical or "engineering science", applied mathematical techniques in the manipulation of existing formulae to get answers to specific tasks, using terms such as "calculate", "evaluate", "determine", and "analyse".

The usual method of problem solution or analysis involved breaking the problem into modules or steps, perhaps involving a diagram that demonstrated the forces or distances, etc, then using mathematical techniques, appropriate formulae and given or predetermined values to produce a numerical answer. This process is a reductionist methodology where the term reductionism has been defined (Collins, 1994) as "the analysis of complex things, data etc into less complex constituents".

One staff member suggested that:

*When we use mathematics and scientific principles in this sort of systematic way it is really a scientific approach, not an engineering approach. The tasks are clearly defined, there is only one answer and the solution is a property of the problem. Lots of our engineering science courses are taught like this, we need these tools and skills of analysis when we do our real engineering work.* *Sstaff7, feedback July 2002*

In this type of analytical problem at the lower levels, the steps were clearly defined to lead students through this process:

*They can like, make a systematic thing out of every problem – like work this first, then that one then that one, step by step not just jumble everything round*
*Teresa, 1st year student 1998*

In more complex problems the "art" came as students had to decide which mathematical techniques or formulae to apply, whether assumptions had to be made, the limits or criteria within which they were accurate, and the like.

> *Maths is part of the route of the whole analysis whether it be structural or a circuit…. And need to remember that analysis often involves approximation often quite sizeable approximation. You are breaking down the real into a model…*
> *Sstaff1, feedback June 2002*

> *Mathematics is a nice vehicle for delivering these ideas – like when you are looking at heat transfer through a wall, using the appropriate mathematics allows you to quantify the heat losses. And being able to calculate and use formulae for the basic mechanism of the process allows you then to extrapolate that to difference applications like flat or curved surfaces. I don't think you could really function without mathematics in these sorts of systems* *SStaff6, Sept 2000*

Students were constantly reminded, by repeated examples, that this aspect of the role of mathematics was important: engineers had to provide solutions that actually worked, bridges, materials and power systems that could withstand their loads, earthquake and wind resistant structures, and systems that would work within predictable constraints and tolerances.

> *…we are the only profession that designs something with a reasonable expectation that it will get built* *HOD1, Jan 98*

Even in subjects such as Environmental Principles, where students were being taught an awareness of the social and environmental impacts and necessity for sustainability of resources, the predominant approach included a quantitative analysis of effects (See section 5.3.1.5).

Staff came from a variety of educational backgrounds and for some the local approach demonstrated a more "applications" focus that was evident in some other countries:

> *Unlike the Indian and American curriculum which emphasises the maths, …I found here it is more formulate learning, they approach maths from the point of view that there is a formula to do this rather than an language to express idea …here it might be at the extreme where they are learning more application oriented so they cant generalise it enough* *JStaff4, Oct 1997*

The second way in which I identified mathematics being used was motivated by the ability to move mathematics beyond its application in predetermined formulae. The majority of staff valued the intrinsic mathematical skills and techniques that underlay the derivations and building of theory. They aimed to move students from the purely technical level to an understanding that would empower them to ultimately adapt and create new theory and techniques:

*…we have gone for a system here where we think students really need to know what is going on inside and can design it. But to understand what is going on they have to do some mathematics. We are caught. The alternative is a building block approach – take one of those boxes and one of those and one of those and connect them up and hey presto – it works… But if it doesn't work then they have no chance*

*HOD1, Jan 98*

*At university you have to figure out where that formula came from, and derive it from first principles. Now that we understand how this formula is derived when anything comes up you can analyse the situation and derive a formula rather than memorise all these formulas* *Samuel, new graduate Civil, 1998*

The student response to this process was often more instrumentalist, and, as the following comment indicated, deep understanding was not always a priority:

*…But the other one, he just does a whole lot of equations, why? Derivations and proofs, never use, just use the end result. Why do we need all these derivations – Loved Thermofluids, they gave handouts which had the derivations on them and they taught what the equation is and how to use it and this is real life things – it is complicated but at least you know why. They said you can work through the derivations yourself.*

*Teresa, 2nd year Mech, Diary7, April 1999*

The third way I saw mathematics being used was mathematical modelling. Students were taught to use traditional mathematical tools to create mathematical models of physical systems for complex situations that would be unreasonable, impractical or impossible to solve by other means:

*Some of these problems end up with huge differential equations that might take a mathematician years to solve for one range of cases, often engineers can't wait so we need to find a way getting a model, or a series of close approximations that can be successively refined to give a "best" answer* *JStaff6, Sept 2000*

From the first year, they were taught the whole modelling cycle, from the initial formulation of the model with its attendant assumptions, through to the actual mathematical construction, to comparing the model's predictions with reality and finally returning to the start to refine the initial model formulation.

It was suggested by several staff that, in teaching the modelling process to students, the constraints of time and simplifying tasks to manageable proportions often resulted in the latter part of the modelling cycle being underemphasized:

*…student tasks rarely proceeded to the further phases of, firstly testing the model with 'real life data', and secondly revisiting the assumptions used to simplify the system and make a model possible.* *Sstaff13, feedback, Diary, April 2002*

Examples in the core Mathematical Modelling courses were drawn from a variety of physical systems including biology, physics, and most of the engineering disciplines. A very simple example of implementing mathematics to model a real life situation was given to the first year class in 1998.

> *It has been suggested that the reason infants become overheated faster than adults in high temperatures is that their surface area to volume ratio is less, therefore allowing less body cooling via perspiration. Use mathematical modelling techniques to prove or disprove this suggestion… ENGSCI 111 lecture, Diary, April 1998*

The process of solution involved first, making a series of assumptions about human body shape (eg a body might be a sphere for a head and cylinders for the torso, arms and legs). With assumptions about typical lengths and radii that might apply to an infant and an adult, the total surface area and total volumes could be calculated. The relative ratios could then be calculated and the hypothesis proved or disproved. There was clearly no "correct" answer for this ratio – although progressive refinements of the models would provide more accurate answers. Simplistic as it was, this example provided an introduction to the methods of mathematical modelling with its concepts of "best" or "optimal" answers.

At first year some students, for whom mathematics had been a very black and white subject that always gave "right" answers, found the concepts of modelling and optimisation difficult:

> *I really remember the way I couldn't solve the first assignment for MM1 – it was like the first time in my life I had encountered mathematical modelling. We didn't understand the point of it. It was actually horrific… Stefan, 1st year 1998*

In later years, the examples were more complex and included much larger numbers of variables and constraints requiring computer-assisted solutions.

Many students enjoyed the problem-solving nature of the maths modelling courses:

> *What struck me was that maths was a tool, it was not the maths that is important, but the stuff that goes with it, applying it to a problem. No point if you hammer the wrong way round, you have to use the tool properly but it's the knowledge of how to use it that is important. The problem solving that goes with it. It links in with the idea of flexing your muscles except they are brain muscles, not normal muscles.*
>
> *Brian, 1st year, 1998*

I observed the influence of mathematics extending into conversation and humour such as:

> *Engineers think that equations approximate the real world. Physicists think that the real world approximates equations and mathematicians are unable to make the connection*
>
> *ENGSCI 111 lecture, March 2000*

and the habit of converting matters of conversational debate into numerical formulae eg proving that a teaching workload is unworkable using a mathematical model to calculate hours available compared to hours required.

Within engineering, there was no sense of skill and ability in mathematics being linked to gender. Students and staff saw males and females as equally likely to have ability or lack of ability in mathematics. Several years of analysis of results of the Mathematical Modelling courses, examining means and standard deviation in tests, projects and examination results provided me with no evidence that within the Engineering school, ability in mathematics was linked to gender. Both male and female students had chosen Engineering knowing that ability in mathematics was a required attribute. These findings appeared to support those of Lips's study (2000), referred to in Chapter 2, which found that third year female U of A engineering students surveyed in 1999 not only perceived themselves as confident in mathematics, but more confident than their male peers. I will return to the relationship of gender to mathematics in Chapter 7.

### 5.2.7 Design – the essence of engineering

The essential nature of Design in engineering was so tacitly understood that I rarely heard it specifically discussed until I interviewed staff for this research. Then, in early 2000 as staff were preparing the documentation for the 5 yearly IPENZ Accreditation Review they were asked to reflect on the role of the Design courses. The strength, even passion, of their beliefs and understandings around the practice of Design teaching was evident:

> *Design is the backbone of the Auckland BE degree – it provides the raison d'être for the engineering sciences by giving students opportunities to exercise their knowledge on engineering applications*
>
> *p.13, Vol 1/Design, U of A Accreditation documentation, August 2000*

Staff commented that the Auckland degree:

> *…has always had a strong emphasis on design, very strong by comparison with any other country* *SStaff5, Oct 1997*

and:

> *…since 1996 when the new degree curriculum was introduced the design content has actually been strengthened by the introduction of project based- learning in the engineering science courses*
>
> *p.13, Vol1Introduction, U of A Accreditation documentation, August 2000.*

The staff saw the design process as setting engineering apart as a discipline:

> *The best place you can find the engineering way of thinking is in the Design courses*
> *SStaff6, Sept2000*

> *Although engineering is based on a similar knowledge set as some other degrees, engineers are taught how to apply this knowledge in such a way as to produce pragmatic solutions to real life problems in a cost effective and timely manner*
> *SStaff1, Oct 1997*

The importance of Design to engineering, and how it incorporates the creative element that at least one lecturer saw as distinguishing an engineering approach from the scientific approach is illustrated in the Powerpoint slide used in the first year Design course (copied in Figure 5.1). For this lecturer, Design dealt with "*open-ended problems, often vaguely defined which always had more than one valid answer*" (Lecture Engineering Design 1B, 2002) and was the subject which "*breaks the barriers between courses, gets the students to make the links and use the engineering science knowledge*".

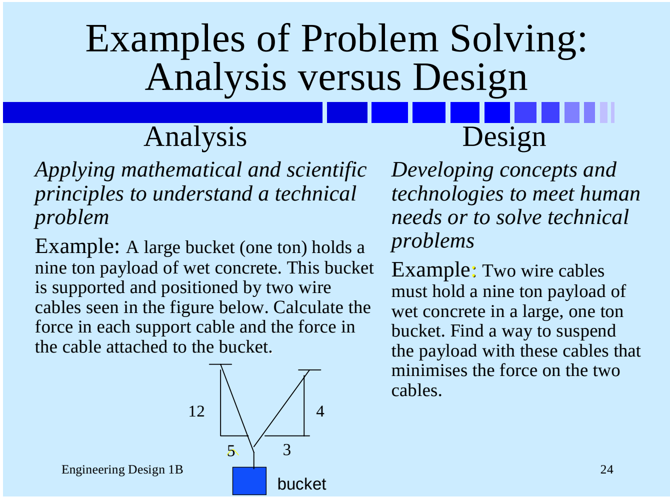


Figure 5.1. Slide from First year Design class. Examples of Problem Solving – Analysis versus Design

Students' enthusiasm for the subject started at first year level:

> *A couple of the projects this year caught everyone's imagination. Put in huge amounts of work*
> *John, 1st year, 1998*

> *I guess the Design paper is the one with the task of instilling that whole engineering mindset into us. I think they are doing pretty well at that. They are doing quite a good job. Leading you into it but not dumping in at the deep end*
> *Laurie, 1st year, 1998*

A truss built with hot dog sticks, had been the traditional first year "design and build" project for a number of years with dimensional and other minor changes. Enthusiastically received by the students, this project dealt with all phases of the design, analysis and build process through to the final testing (to destruction) of the structure:

> *It had everything. Teamwork, moving from a complete conceptual brainstorm to designing, building and testing, it was the whole shebang. It was like a mini project, what you do out in the world, all the facets of making something.*
>
> *Angus, 1st year 1998*

In this project, the first year students also learned that engineering design was likely to produce an optimal solution rather than a single right answer:

> *No way you can write down equations to solve this problem – and this is quite often true in design. Start with an idea and test. Nobody knows what is the 'best' design until actually finished and tested and even then is the strongest design actually the 'best'?*
>
> *Part 1 lecture, diary, 5/5/97*

The valuing of Design was manifested in the curriculum by the inclusion of a design paper in each discipline at each level for the first three years, and projects set in a significant number of courses. Projects varied in complexity and scope across the departments, and were not all of a "design and build" nature, but for each department were incorporated in ways relevant to each discipline. In Civil Engineering, for example, students worked on projects ranging from the design and analysis (by hand or using computer methods) of single storey buildings and bridges in timber, structural steel and reinforced concrete, to the major design project in the Water Resources Engineering paper, which typically focused on the design of aspects of a multi-purpose water reservoir scheme incorporating feasibility stage design work in an environment intended to resemble real-life. In Mechanical Engineering, each year's Design paper featured one project which was a "design and build" – some of which, notably the "steamcar" and "Warman project", had become traditional highlights of the Mechanical Engineering program.

An example of the design focus in Electrical Engineering was an industry sponsored project for Year 3 design which required students to research, then design and build a device which would take the movement of a yacht's wind vane, convert it to an electrical signal, determine the wind direction to an accuracy of $1^{o}$ and display it on an LCD. This type of project gave rise to the comment:

*Our course is more practical and project based than many from overseas as we see when students come here from overseas and are usually totally out of their depth in a practical sense* *Sstaff6, Sept 00*

Evidence from course evaluation audits, and the students I interviewed and surveyed, overwhelmingly demonstrated that the students enjoyed their design courses, the final year projects and those papers which "*relate what we are doing to the real world"* (QuF3). Design papers provided a chance to "*apply the theory learned in other papers to find practical solutions*" (QuM7) and "*allow me to understand how structures work*" (QuM1).

Design subjects were also exemplars of the use of a "top down" or reductionist approach to problem solving. The majority of design projects were group projects, designed to be too complex to be done by an individual in the time available, and in first year Design, students were introduced to two techniques reflecting this way of thinking.

The first was the idea of Objective trees as a helpful tool at the design specification stage. Using a diagram such as Figure 5.2 the students were encouraged to take the problem definition and break it down into more specific terms, repeating the process until all required attributes were defined clearly. The resulting diagram, it was suggested, would then be the basis for setting up a design specification report.

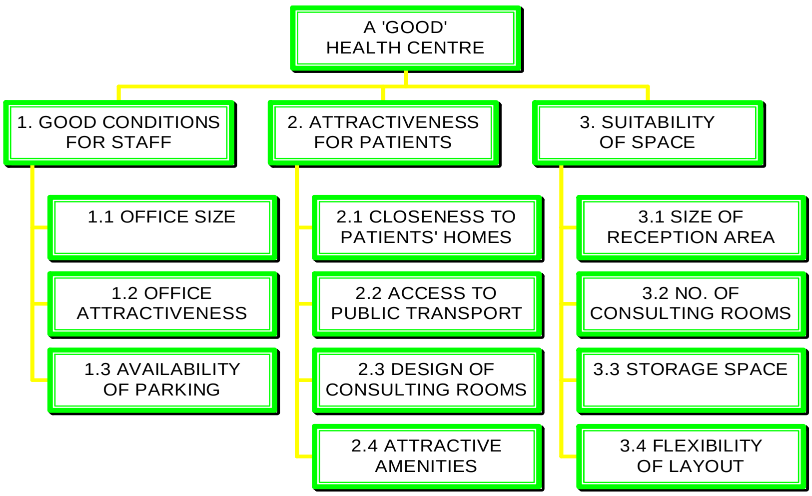


Figure 5.2 Development of System Objectives (Powerpoint slide, Engineering Design 1B lecture, 2002)

The second technique, which appeared to become a practice so taken for granted that it was rarely referred to by name, was "Work Breakdown Structures" in which students were encouraged to break down the overall task into layers of tasks and sub tasks which were then allocated to particular team members with deadlines for completion.

The engineering staff with whom I discussed this approach were unfamiliar with the term reductionism "*that is a social sciences sort of word…*". They were, however, very familiar with the concept of "top down methodologies" which were seen as prevalent not only in Design and projects, but across all engineering disciplines and courses where complex systems were involved:

> *I use a top down methodology of analysis in subjects like Systems Engineering – start with high level of abstraction and break it down step by step. It is the only logical way to do it isn't it?* *Sstaff7, feedback July 2002*

> *Part of the analysis process is breaking down a complex thing by a process of logical deductions into manageable chunks but remembering to bring it all back together again as part of the big thing… – the whole thing is a top down methodology…*
> *Sstaff1, feedback June 2002*

### 5.2.8 Project based learning and the balance with traditional pedagogy

Implementing the goal of increasing the amount of project based learning was seen to have advantages as well as disadvantages for both staff and students:

> *It is enormously hard work preparing new lecture material. Project based learning while I am sure it is a good idea, is extremely time consuming and difficult to set up and in the last two years some of us at least have put an enormous amount of time into making it work. The students seem to enjoy it* *JStaff1, Jan 98*

> *Need a balance between standard courses and PBL – I do believe that most mere mortals can only do one project at a time maybe Geniuses can do two and God might do more than two. It is important not to have too many courses setting projects simultaneously* *SStaff6, Sept00*

> *I had real apprehensions about moving to too much project based learning as it was so resource intensive and we just didn't and probably would never have the human or material resources. Needed a balance – think we have enough as it is now*
> *SStaff8, Aug 00*

By the end of 1998, when the first three years of the new curriculum had been taught, a special Faculty meeting was called (18/11/98) to discuss Project/problem based teaching in response to some staff concerns. The Chair of the meeting, reminded staff of the motivation for the change to the new curriculum and that:

> *…we already have project based teaching to a larger extent than the USA and UK, and what we have really done is "ramp" it up into other papers.*

As he opened the meeting up for comment, it became clear that the major concerns were with the balance and tradeoffs involved in incorporating more project based learning in to the teaching. On a positive note there were comments such as:

> *…enormous maturation of students – not used to independent thinking, see them grow…*
>
> *The logistics is hard but the positive outweighs the negative…*
>
> *…we need them to be able to do things – knowledge based skills – not just know things. Otherwise you might as well be a scientist not an engineer – really need the projects to ensure they learn these skills…*

and as issues that needed addressing, staff identified:

> *Difficulties with space – for small group meetings and working, they occupy labs for a longer time…*
>
> *Problem based teaching opens a "can of worms" – presentation becomes too important, they're good at "dollying it up" – using computers results in great presentation but danger, zombie approach, not thinking it through…*
>
> *I am not convinced the reduction of lecture hours has resulted in an increase in private study, projects take that time away from learning content….*
>
> *Too many projects kill student enthusiasm and a sense of a 'good job done'….*

The overall consensus was that:

> *We may have gone into it naively, but there is no going back …*

and that what was really needed was for teaching to use an "*armoury of tactics*". Too much project based teaching was seen as too demanding of both staff and student resources and time. The following comment seemed to exemplify the tensions many of the staff felt around the problem based approach to teaching:

> *I really believe in the project based approach but it would be much easier for your career and quality of life not to do it.* *SStaff7, Apr 01*

### 5.2.9 Teaching practices

Despite the rhetoric and motivation of a curriculum which encouraged contextual learning and project based teaching, the majority of the teaching in engineering was still content and lecturer centred, with the teacher the authority and the students the "*empty vessels*". There were staff who spoke of students as "*not vessels to fill but fires to light*"[2] but I saw the pragmatic realities of modern universities – large classes, diminishing funding, overstretched staff, and students who were paying high fees for their education. For many courses traditional teaching methods were the most economical to resource. In the School of Engineering lecture class sizes were usually relatively large, ranging from streams of 250 at first year, to between 60 and 120 at second, third and fourth years. Only in final year elective courses, or in the relatively small classes of the Chemical and Materials, or Engineering Science sub-disciplines were class sizes less than 40.

> *Teaching methods have been variable to say the least. Some papers have been taught in the old style method, given notes, told to learn them, given problems to do. Not that is a bad thing, it suits some courses more than others. Then others style of teaching has been quite challenging, dissimilar to what you have encountered before… Have to learn to adapt* *Laurie 1st year,1998*

> *Mostly you were taught… the standard lecturer up the front – the odd person would try and incorporate examples, like teach you how to do something and give you an example and then walk around and make sure you got it* *Chloe, 4th year Mechanical, 1997*

Although professional development in teaching was offered by the university, my perception was that many staff thought that they knew how to do it: after all they had themselves been students and through the same system:

> *The reality is that for most of the older staff, experience goes back to the way they were taught and they simply continue that style, the younger staff members coming in, are more open minded.* *AssocDean, Oct 97*

There were a large number of lecturers who, from my observation of classes and discussions, put a lot of effort into using "best practice" teaching methods even in big classes although they obviously found it easier in the smaller classes:

> *Definitely more interactive in my teaching now… it depends on the class size. In the smaller classes I will set problems that they have to spend five minutes or so working on and go through them and also just asking them questions and waiting for an answer*
> *Jstaff2, Oct 1997*
> *…the biggest difference, I bring in a lot of examples which I wasn't able to do when I first came…now if I have 50% of the lecture prepared I can almost wing the rest of it. Because of the examples, I can ask more questions … but it does depend on the size of the class* *SStaff4, Jan 1998*

Lecturers at Part 1 were chosen particularly for their ability to maintain student interest and control of the large classes and students appreciated the efforts those lecturers had made:

> *Just about all lecturers had heaps of energy and/or passion about what they were teaching.* *Michelle, 1st year 1998*

Powerpoint presentations using data show, the use of videos and slides, were common and an increasing number of lecture notes were being made available on the Internet. As engineers, many lecturers felt they should "role play" the use of modern technology. Standards were variable and, particularly in the latter years of the degree, some lecturers continued to use hand written notes or hard-to-read Overhead slides:

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[2] Guillemin, B. Seminar to staff "The professional, teaching and research nexus" 18/10/2000

*…there is a really big shift between the "old school" lecturers and the "new school" lecturers. You get the idea that there is an old school which in the traditional way gives you the theory …and the new school – people who do design and stuff and they have more of an idea what it is really like. They are more inspirational, more interactional, getting participation…* *Angus, 1st year 1998*

Staff perceived that their teaching had to deal with students who were increasingly adopting a very instrumentalist approach to their education – "answer oriented" rather than "process oriented". Their expectation, it appeared to staff, was to be provided with information that was "*ingested*" and later "*regurgitated*" via exams or tests. Spoon feeding was a term used for the type of teaching, which did not require students to engage in the process of learning:

*I am concerned that lecturers believe they are teaching for understanding and that this is what students should be striving for – understanding and challenge – but my observation is that students only think of grades – "Is it in the exam" – "What does it count for"* *Assoc Dean, Diary, Sept 1996*

*Staff members have detected a shift in student objectives. In the past students primarily came to University for an education; today, for some students there is an implied transaction: in exchange for the student loan they obtain a degree which will enable them to repay the loan. The significance of this observation is that we think some students adopt a mechanical approach to their studies and are less motivated*
*School of Engineering Annual Report 1997*

*Some people believe that teaching is increasingly becoming spoon feeding – Factor of the pedagogical climate – idea of university as a place where they find things out for themselves has gone – some of that can be based on having to pay their own fees – their attitude is " I paid my fees – now just help me get out of here"* *SStaff3, Sept 2000*

*Lecturers need to realise we pay a lot of money and should therefore receive a quality education* *Questionnaire F5, 1997*

It was recognised that external factors, beyond the control of the School of Engineering, may have been partly responsible for some of these student attitudes:

*The Semester system, pressure of time, no time to work through the pain threshold, to challenge the obstacle, they don't get the confidence to give it a go.* *HOD1, Jan98*

*I am shattered at the amount of time students are working part time – that is behind the "spoon feeding" – a hell of a lot of students are doing 1/3 time jobs and some are almost working half time. I don't know how they are doing it* *SStaff3, Sept00*

The prevalence of part time employment was confirmed by the Course Experience Questionnaire, which was trialled at the U of A in 1999 for BE graduates and found that approximately 25% of graduates reported doing more than nine hours part time work in their final year.

A feature of teaching practice was the interdisciplinary co-operation and interaction that was evident in the delivery of the curriculum. The core subjects of Mathematical

Modelling and Professional Development brought together students from each sub-discipline, and several subjects such as Mechanics of Materials were taught to students from more than one department. Staff also taught outside their own departments in ways which were felt to be unique on the campus:

> *We (Chemical Engineering) interact with other departments like Electrical in Control, Civil in Fluids and Hydraulics and Resource with Waste treatment whereas in the Science faculty they don't – we are a bit unique in our interdisciplinary links*
> *HOD2, Jan 98*

Interdepartmental co-operation was evident also at the research and project level. Most research group groups linked with other engineering departments and several also linked with other faculties e.g. Bioengineering and Materials Engineering. Research funding was allocated by research clusters which encouraged the formation of interdisciplinary links:

> *Here there is more collaboration between one department and another… a school approach whereas at (another university) it is every department fighting for itself. We can have projects with Civil Engineering and us, or Mechanical Engineering and us, or with Engineering Science and us, and we do that to a level that is unheard of in most other parts of the university. It is not regarded as difficult …it is no big deal …in our school it happens easily* *HOD1, Jan 98*

### 5.2.10 Inclusive teaching

In Chapter 2 reference was made to institutions which had specifically worked to ensure that content, assessment and teaching styles were gender inclusive. When I questioned staff members about this aspect of teaching, there was very little understanding of how their teaching could be altered, why it should be and what gender inclusive might mean in the context of engineering education. It was generally assumed that gender inclusivity referred to content, which was seen as inflexible and gender neutral:

> *The material is dry and technical – hard to have questions and discussions. Wouldn't want to choose specifically female friendly examples – wouldn't want to appear patronising – I try to choose examples of interest to all – am aware of trying to do that*
> *Jstaff1, Jan 1998*

> *I don't understand the term – the lectures that I have given in Materials – I don't see how I could have given them a different way – if the whole lecture theatre had been full of women I don't see how it would have altered the words that I used*
> *Dean2, Jan97*

> *I guess it might mean rendering curricula equally of interest and value to both sexes. But I don't think the curriculum is gendered – the problem is more the learning environment and learning procedures that are used*
> *Questionnaire, male Sstaff1 1997*

Very few staff appeared to have any exposure to a theoretical understanding of different learning styles. Most usually worked from instinct and prior experience.

> *When I set assessment questions I often seem to think a different way to the students. Hard to explain but I seem to think more graphically, and with diagrams whereas my students want to work with formulae and numbers. It seems to be difficult to adapt to someone else's way of understanding, so the best I can do is to try and use a variety of questions.* *Diary, SStaff, 4.5.98*

More commonly, lecturers attempted to "*provide examples that would interest all students"* and there was an awareness of the need to use terminology on assessment questions which would not prove difficult to English second-language students.

The University Equal Opportunities Strategic Plan required faculties to report on ways in which they had included the interests and contributions of under-represented groups, particularly Maori. The curriculum of the Professional Development courses provided and examined material on cultural differences, particularly the application of the Treaty of Waitangi, but I did not find examples, even in these courses, of the "contributions and understandings of women and ethnic groups" to engineering.

Some staff believed that female students generally had better communication skills than their male peers, and other staff thought females had difficulty with 3D spatial visualisation, but on the whole staff had not noticed any differences in learning style or ability that could be differentiated on the basis of gender, and certainly none that would have caused them to make changes in their teaching practice.

### 5.2.11 Problem solvers, not problem framers

A theme running through the teaching practices and evident also in assessment practices in the next section was the understanding which appeared to be common to both staff and students that engineers were problem solvers:

> *…new graduates say that their engineering degree has trained them to sort out new problems – how to go away and work out how to sort it out – gaining a way of thinking…* *Diary, SStaff3, Sept 2000*

> *Course designed to introduce contemporary industrial problems and the techniques used to solve them… …We adopt a project based learning approach where students will learn through active participation in analysing and solving an industry based problem.*
> *SStaff7, April 2001*

> *I think with engineering there is an identity of getting stuff done or achieving stuff. You are always having to build something or to design something to meet a specific problem*

*and that is what drives you. To innovate in such a way as to fill a need or get a task done*
*Brett, 4th yearE&E, 1997*

Few of the staff or students interviewed questioned this role of engineers as problem solvers, usually viewing it with pride, but I found it noteworthy that there was some recognition that the educative process did not really address the issues of who set or defined the boundaries within which the engineers must work, and whether engineers should be more involved in framing or questioning the problems they were asked to solve:

*That is what I said in one of my lectures – engineers are taught how to find the solution, but not question whether the solution is required. …I think the perception of society is that engineers are responsible for a lot of the screw ups in our environment… if engineers were a bit more aware of the potential negatives before they just go on and provide the solution there would be differences in the way things are done…*
*Jstaff5, Oct 1998*

*I would put it down to our training, the way we are taught to think and act. Taught – we want to put a road here and we are taught how to put the road there and not should the road really go there, or over there or should it be there at all*
*Samuel, new graduate Civil, 1998*

## 5.3 Assessment

The Assessment Policy, circulated to all staff of the U of A in May 1999 stated that *"Properly selected assessment tasks indicate the importance of particular content, concepts and skills, influence approaches to study, and help students to allocate their time appropriately*". This document recognised that assessment tasks and practices manifest the value placed on particular skills and knowledge by the academic staff, and indicate that they also influence the behaviours of students.

Some assessment practices are governed by regulations and procedures. At the U of A, a set of guidelines is provided to examiners and assessors, to ensure that the integrity and quality standards of the university are maintained. Contained with those regulations and guidelines are procedures which have implications for the culture of academic disciplines. One of these required the grading of students in a ranked fashion, predominantly using a norm referenced system. It appeared to me that this norm referenced grading system was deeply ingrained in higher education although the Assessment policy acknowledged, "*university teachers should move towards using criteria consistently from year to year …and accept that the allocation of particular grades may fluctuate from year to year".*

In the School of Engineering, guidelines were issued each year reminding staff of the approximate percentage of A grades, B grades etc that should be awarded in each course. The Associate Dean explained the need for these guidelines to me in terms of equity between courses and across departments, particularly in light of the award of Honours, which is discussed later in this section. The norm referenced grading system caused problems in engineering courses such as Design. In these courses, students were usually given a design brief, which included a set of objectives and constraints. If a design met its brief, and accomplished the task it was designed for, it was difficult both to award a low grade and to rank students. The consequence was that grades in these courses were invariably higher than other courses and the student perception was that *"you can't fail design courses"*.

The University-provided guidelines required students at the beginning of each course, to be provided with the assessment schedule, including dates. The University policy also stated "*assessment activities should be designed in conjunction with formulating clearly stated learning aims and objectives*". I found from an examination of a range of course outlines and assessment schedules provided to students, that the majority did not provide clearly stated learning objectives or even expected learning outcomes. It was more usual to see a brief, generalised aim such as these:

> To learn techniques for the characterisation of particles and particulate systems and to gain an understanding of the fundamental concepts concerning particulate systems.
>
> CHEMMAT 316

> The aim of this course is to extend students' knowledge about the fundamental processes which take place in most energy conversion systems. The primary focus of all these processes will be the energy transfer within large power station boilers, some of these processes are however common to all energy conversion systems.
>
> MECHENG 413

or no aim at all. A list of the lecture program contents was almost always included. Specifying the content to be taught in each course appeared to be seen as carrying implicit assumptions about the skills and knowledge which would demonstrate understanding and a successful outcome for the course. I observed that the discourses of education and curriculum design were unfamiliar to a significant proportion of the engineering lecturers, who were not comfortable with terms such as "learning objectives".

Design courses and those with a high component of project based learning were more definitive in stating learning objectives or outcomes, perhaps to make clear to students the basis on which they would be assessed. In these courses, students were usually given a course aim couched in terms of their learning outcomes:

> The aims of this course are for students to learn:
> To adopt good professional engineering work practices
> To learn the design process through problem solving and design activities
> To develop written and communication skills
> To develop skills in sketching and drawing
> To understand what professional engineers do
>
> Engineering Design 1

or quite precise project and learning objectives, as in the 4th year mechanical engineering design course:

**Project C2 Dynamics and Control**

| | | |
|---|---|---|
| Project Objective: | | To investigate the use of low-order approximate modelling in Control Design. |
| Learning Objectives: | 1) | To become aware of a representative biomedical control problem |
| | 2) | To become conversant with time delay representation and simulation using Padé Approximants |
| | 3) | To understand and apply low-order modelling techniques to the system |
| | | … |

Awarding of Honours

For a fixed quota of graduating students the four-year degree was awarded with Honours based on the results of the final two years of study. Approximately the top 20% of students, ranked across all disciplines, received First Class Honours and the next 20% Second class Honours, but each year the exact cut off line was decided at an examiners' meeting of all academic staff. No efforts were made to ensure that any department or degree specialisation received a proportion of the Honours grades (although I noticed it was carefully monitored by each of the disciplines), and the system did not take account of the average entry qualifications of the cohort which was graduating.

The awarding of Honours was a long standing tradition for the engineering degree and rewarded excellence in academic achievement. The need for equity and fairness across the disciplines in awarding Honours was one of the reasons given for the traditional guidelines of giving approximately 20% A grades in each course. The Honours system had the potential to cause a competitive environment especially among the “able” students and I have commented further on this response in Chapter 6: Behaviours.

### 5.3.1 Assessment – learning what is valued in first year

As I watched first year students I became very aware of the importance of the role of assessment to the processes of enculturation. I saw first year students quickly learn which responses and learning resulted in the higher grades, which it appeared they equated with success within the culture. For this reason I now present an in-depth analysis of a selection of Part I common core examinations and assessment tasks for the years 1997 and 1998 with the aim of identifying the role assessment played in the development of first year students’ learning of which skills and knowledge were valued within the culture.

#### *5.3.1.1 Mathematical Modelling 1*

In 1998, when I interviewed first year students for this research, the Mathematical Modelling course had short weekly assignments, plus two projects and one test as well as a three-hour examination. The majority of weekly assignments were focussed on essential mathematical skills, with only brief forays into their application to mathematical modelling, eg:

> The brightness, I, of a planet as seen from earth varies directly as the albedo, a, directly as the phase, p, directly as the square of the planet’s radius, r, inversely as the square of the planet’s distance from the sun, s, and inversely as the square of the planet’s distance from the earth, e (the albedo is the proportion of sunlight reflected from the surface and the phase is the proportion of the planet’s disc illuminated by the sun). Write down a model for b in terms of the other variables, incorporating all of the above information.

The projects were opportunities to model real life situations, applying the principles and techniques of mathematical modelling, and seeking optimal solutions to a range of problems. One example was a project using the theory and formulae of illumination. After providing the background theory of luminous intensity from a point source and a long line source, the context of the problem was stated as:

> After a number of years, when the power crisis is finally ending, a company decides to locate its factory in one of the empty buildings on Queen St to take advantage of the labour pool of unemployed lawyers and accountants. The factory contains an 8m by 1m workbench at which seated workers do detailed assembly work. It is illuminated by a line of four 200W light bulbs which hang above the long axis of the bench and symmetrically about its centre. The two inner bulbs are 2.6m apart and the outer are 7.8m apart. The lights need to all hang at the same height and to be placed at least 1m

> above the bench in order not to interfere with the workers. The variation in illumination needs to be as low as possible. The minimum illumination recommended for close work is 100 lumen/$m^2$. The whole table needs to be illuminated according to these constraints. (A table with values of the illumination at the centre line of the bench for various heights above the bench and distances from the centre was given.)

In this project the students were given a simulated "real life" problem with situational details and constraints within which to solve the problem. I noted the "put down" of accountants and lawyers and its implication that engineers were superior – another small contribution to their enculturation. The context of the problem was emphasised as local by reference to the recent power crisis in the central business district.

Assessment tasks in this project were not only mathematical, eg:

> Obtain a formula for illumination in terms of h and x and use a value from the table to check it is correct.

but required the student to make judgements and assumptions:

> How would you model this situation to obtain a simple mathematical model? What assumptions would you make?
> Investigate the placing of the lights relative to the bench so as to meet the required constraints. Justify the values you have chosen.
> Discuss the accuracy of your recommendation in the light of your assumptions. Is accuracy to 10cm reasonable?

First year students in this type of project were learning not only the mathematical skills that would be required of them, but how those skills in real life must be used in conjunction with contextual knowledge to make assumptions and be able to justify them.

Engineering students learned by this sort of example that, rather than one correct answer, the concept of a "best" answer was more likely in engineering, within the boundaries of a set of specific constraints and always backed up by appropriate technical theory and calculations.

The final part of this project, which overall was worth 20% of the student's final grade, was to model the existing lighting scheme in the underpass from the School of Engineering to the main campus. Here an extension of the illumination theory was provided, and skills in trigonometry, integral calculus and algebra were needed to derive appropriate formulae. After analysing the current scheme, including taking measurements, the student was to make suggestions for improvements, and design and analyse an alternative scheme, with the answer to be presented as a formal report.

Method and process were valued in this type of project. Projects were seen by staff to be a better assessment instrument for students to learn and demonstrate their understanding and ability to apply mathematical modelling skills than the time constrained environment of a test or examination. It was noteworthy also that the communication skills, such as report writing, which had been taught in other courses, were reinforced in this project in the following instruction:

> Your answer to Question 2 must be presented as a formal report. As an appendix you should include a technical section in which you present your calculations etc. but the rest of your report should be written in non technical terms.

The examination in Mathematical Modelling in 1998 was mostly testing skills such as differentiation, solution of simultaneous equations, matrices and vectors – all of which had been used in modelling examples through the year. One modelling question was included, reiterating the need to make informed assumptions:

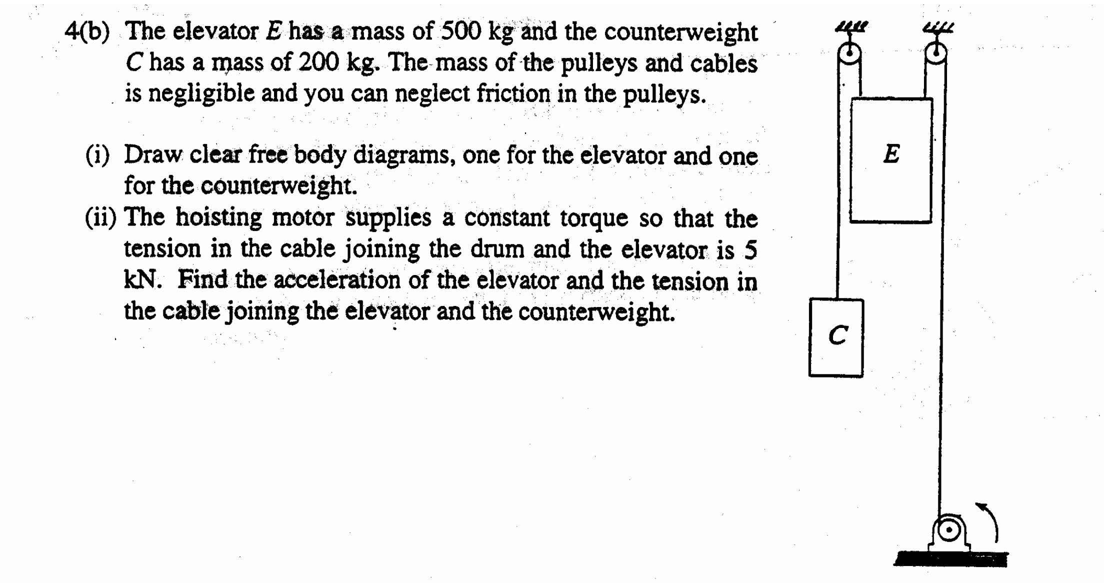
> List 3 reasonable assumptions that can be made to help simplify this problem…
> List relevant factors associated with this problem, giving suitable symbols…

The examination questions testing mathematical skills used gender neutral examples and contexts that were likely to be within the experience of all students eg. water fountain, opinion poll, device to measure depth of river, tank used for diluting industrial waste, or rate of change of volume of a cancerous tumour. The gender neutrality of assessment items was matched by the lack of statistically significant gender differences in the assessment outcomes for this paper. I have provided an analysis of examination results for this paper in Appendix 12.

#### *5.3.1.2 Engineering Mechanics*

The Engineering Mechanics course was taught and assessed in a traditional lecture, test and examination style. After setting weekly problem sheets, which were corrected in tutorial sessions, there were two tests during the semester rather than assignments or projects. I have used a detailed analysis of a question (Figure 5.3) and its solution from the examination in 1998 as typical of the techniques used in Mechanics assessment.

I saw this question, and others like it in this introductory course, as representative of the reductionist methodology prevalent in many of the later engineering courses.


4(b) The elevator *E* has a mass of 500 kg and the counterweight *C* has a mass of 200 kg. The mass of the pulleys and cables is negligible and you can neglect friction in the pulleys.

(i) Draw clear free body diagrams, one for the elevator and one for the counterweight.

(ii) The hoisting motor supplies a constant torque so that the tension in the cable joining the drum and the elevator is 5 kN. Find the acceleration of the elevator and the tension in the cable joining the elevator and the counterweight.



Figure 5.3 Question 4b, Engineering Mechanics 1998

At first glance this is a question based on a real life context – an elevator would be known to most students (except that in NZ, people movers which operate in shafts are known as ‘lifts’ not elevators – was this an example taken from an American textbook? Would students already have met examples in class or tutorials which mentioned ‘elevators’?).

The question was testing an understanding of the forces acting on two bodies whose motion is connected through pulleys. The bare essentials diagram was provided with all necessary information about the mass of the elevator and the counterweight. Although students would, by exam time, be familiar with this type of diagram, and have done worksheet problems with pulleys, the lecturer identified that pulleys had not been brought into any lecture and it was possible that some students may not have seen one or had any experience with them. There appeared to be an implicit assumption that students would connect the diagram to a visual image of a real life situation but the lecturer questioned whether for most students this was the case:

> *I don’t think the students will actually think about an elevator or lift, but just think ‘box connected to another box by pulleys…’ – I think they just do it, some don’t even want to draw the free body diagram, because they have to understand the physical forces to draw the FBD, they just want to ‘do the numbers’ Jstaff7, Diary, May 1999*

This confirmed my own experience when tutoring students. They could work this type of example in practice, and often appeared to mechanically follow the steps to solution without any real experience or understanding of the practical implications of the forces, torques, etc that they were calculating.

The free body diagram requested in the question above would look like Figure 5.4.

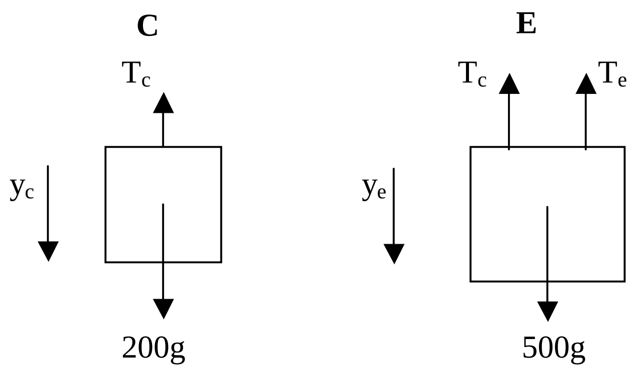



Figure 5.4 Free Body Diagram for Question 4b, 1998

The context of the example was stripped away completely and lines, directions, angles and numbers were now the tools being used. Having been given the value of the tension in the cable, the student was then asked to do a calculation of the acceleration of the elevator and the tension in the other cable.

The expected solution would look like:

*(ii)* *for C* $\Sigma F_y = ma_c$ $200g - T_c = 200a_c$ *(1)*

*for E* $\Sigma Fy = ma_e$ $500g - T_c - T_e = 500a_e$ *(2)*

$a_c = -a_e$

*(1)* $200g - T_c = -200a_e$ $\Rightarrow$ $T_c = 200(g + a_e)$

*(1) ->(2)* $500g - 200(g + a_e) - 5000 = 500a_e$

$300g - 5000 = 700a_e$

$\Rightarrow$ $a_e =$ *-2.94 m/s2 upwards*

⇨ $T_c = 200(9.81 - 2.94) = 1374.3$ *N*

⇨

The principles and formulae required are implemented, and using mathematics the answer was found. A box was given to put the answer in, and standard marking practice was that even with a wrong answer indicating an arithmetic error, correct process could result in some marks being given.

As noticed in the above solution, solutions to problems in mechanics rarely involved words or explanation. Problem solution was demonstrated through the appropriate use of mathematics and equations, with the assumption of a shared set of understandings based on common knowledge and practice.

> *The line (1)* $\Sigma F_y = m\,a_c$ $200g - T_c = 200(a_c)$ *in the model answer was as good as a sentence to me. The student is applying Newton's 2nd law to the body C – summing the forces and making the total equal to the mass times acceleration of the body* *Jstaff7, Diary May 1999*

Students brought widely different background experiences to this subject. Mature students, who brought practical experience but lacked a recent background in mathematics, had difficulty with the mathematics but often had a good grasp of the physics. Whereas those with almost no practical background, often women but not exclusively, were often highly competent mathematically and academically but not confident with questions which might include examples such as pulleys, rear wheel drive cars, pistons and crankshafts, which lay outside their personal experience. One tutor recognised this lack of experience and brought a piston and crankshaft into his tutorial. After explaining their use, he was astonished to be asked by a female student "*so if you have a four cylinder car, do you have one of these on each wheel?*" (Diary, 1998).

The Mechanics course was the only first year course over the period of this research for which female students consistently received significantly lower average examination results than their male peers (See Appendix 12).

It was unclear how much the lack of prior experience relative to mathematical ability or lack of dedicated study contributed to the conceptual difficulties, but one female student commented:

> *I just don't feel good about mechanics, it seems like everyone else knows about pulleys, and rear wheel drive cars and forces and I don't know if I have got all the stuff I need, or whether there is something else I am meant to understand.*
>
> *Michelle, Diary 6, 1999*

Based on the statistical evidence of lower performance by female students, combined with their perceptions of difficulties, peer tutorials were organised annually by

Liaison WISE in this course to mitigate, although clearly not eliminate, these outcomes.

I suggest that assessment tasks in this course ensured that students had not only gained knowledge and understanding of the scientific principles of Statics and Dynamics, but had also trained the students in a reductionist methodology – a way of problem solving that would become common in later years for many of their technical subjects.

#### *5.3.1.3 Materials Science*

Students enjoyed this second semester course. The lecturers were interesting, even passionate about their subject and the labs did "*real experiments*". However, the difficulty and relatively high failure rate of the tests and exams appeared to come as a shock to the students. This course had two tests rather than projects or assignments.

Students were surprised at the assessment style, with a perception that little practice or indication of the type of questions had been given in the lectures which were seen as anecdotal and chatty rather than providing good lecture notes:

> *The lecturers said the test was based on concepts and ideas and the test was numerical. Some people were a little bit dismayed and asked What the heck is going on, and how can we study for test when we don't know… Laurie, 1st year student 1998*
>
> *He is asking the questions which are tricky, not only because of the wording – but it is like he is enjoying giving us the most tricky questions possible.*
> *Alex, 1st year student 1998*

The assessment tasks in both tests and examinations were unlike any that had been met in the first semester. The examinations were almost entirely multichoice or short answer with large numbers of technical terms (112 in 1997) such as "eutectic, proeutectoid, pearlite, martensite, necking, quenching" which would have been new to these first year students. Every half mark was accountable. For a 180 minute exam, questions such as that quoted below, worth ½ mark each, would have had a time allocation of 1 minute. Each of these multichoice questions required the recall of at least five technical terms, and it seemed unsurprising to me that the students saw this style of questioning as requiring rote learning instead of understanding:

> Which single statement is true?
> A Austenite has maximum carbon substitution solubility of 2% at about 1130$^{o}$C
> B Ferrite has extensive interstitial solid solubility of carbon near 728$^{o}$C

C Pearlite, martensite and grain-boundary cementite are all examples of nucleation-and growth decomposition products of austenite
D The hardness of tempered martensite is inversely proportional to its quenching rate
E None of the above

I noted that it seemed unfortunate that the well-received practical examples used in lectures (eg the freezing of metal on the Liberty Ships, the corrosion of the Harbour bridge welds, and the spaghetti demonstrations illustrating the properties of long stranded polymers) were not used in questions to illustrate understanding. No questions requiring written explanations such as “*which material would be better to use in … context and why*” were to be found. In 1998 there was a “which material’ question but it was based on a calculation:

> Calculate the thermal shock parameter for three ceramic materials whose tensile strength, elastic modulus, thermal expansion coefficient and Poisson’s ratio are given below, then state which ceramic material would be the best candidate material for an application where thermal shock is expected to be a problem.

Understanding in this question was demonstrated through the use of appropriate mathematics and formulae rather than words.

First year students, the majority of whom were straight from high school, identified that the school system had prepared them for process and application of facts rather than rote learning, and that this type of examination did not allow room for deduction, opinion or thinking:

> *You have to know every single little detail about this material like if it was X64 you have to know every single thing like the melting point and everything. It was multichoice and they have very similar answers, so you have to know every single little detail… But when you need to know exact facts you can’t make it up…*
>
> *Sue, 1st year 1998*

From my discussions with the teaching staff of this course I inferred that the style of assessment was a response to the size of the class (450 in 1998) and the need for ease of marking under time and resource constraints. This pragmatic response to assessment by the staff resulted in a practice that they viewed as less than ideal in terms of assessing students’ understanding.

#### *5.3.1.4 Electrical Engineering Systems*

The Electrical Engineering systems course, also in the second semester, had one test, a practical project (building a transformer), and a 3 hour examination. The majority of the examination questions for this course were of the short answer type which required diagrams such as circuits, mathematical calculations or definitions of terminology. A typical question from the 1997 examination used "describe, explain, derive, calculate" to extract from the students the extent of their learning, eg:

> 5(a) **Describe, with the aid of simple diagrams**, the principle of a strain gauge transducer. **Explain** some applications for the device
> (b) **Explain** the principles of the half bridge configuration used with a strain gauge. **Derive** the output voltage $V_o$ in terms of the supply voltage, $V_s$, the nominal resistance values, R, and the change of resistance in the strain gauges, (delta) R.
> (c) Consider the circuit in Figure Q5. **Calculate** the output voltage for this circuit.
> (the bold highlights are my own)

One objective of the new Part I course was to "demonstrate the constraints and realities within which electrical engineers operate – the social and environmental responsibility perspectives". The 1997 examination had attempted to explicitly value the ability to communicate opinion on social and environmental issues via open 'essay type' questions such as one on alternative energy:

> Great Barrier Island lies some 20km north of the Coromandel peninsular. Tryphena is a small settlement on the island and clearly it would benefit from a low cost reliable electricity supply. There are a number of options for such a supply ranging from an underwater cable from Coromandel, or a local diesel or gas powered generator, or a generator powered from renewable resources on the island, such as wind, solar, wave or tidal power. There may also be a small hydro resource. Discuss the renewable options for Tryphena and outline their relative advantages and disadvantages.
> ELECTENG 101 exam, 1997

In 1998 a similar question attempted to reflect the professional orientation of the course, and deal with an environmental issue, but it had moved to a quantitative way of analysing a professional decision i.e. the wisdom of an investment in a new power scheme:

> A landfill refuse dump produces gas at a rate of 850 kg/hour. The gas has a calorific value of 8MJ/kg. At the present time the gas is piped to a small local community and burnt to provide district heating. The boiler has an efficiency of 85% and the value of the heat produced is 0.6c/MJ.
> In a new development it is proposed to burn the gas in a modified diesel engine and use that engine to produce electricity. The diesel engine efficiency is expected to be 18%. The power from the diesel engine is converted to electricity in a three phase synchronous generator with an efficiency of 95%. The exhaust from the engine can still be used for district heating with a heat exchanger efficiency of 80%. The value of the electricity is 5cents per kW.
>
> (a) Draw diagrams showing the essential elements in the existing scheme and in the proposed scheme
> (b) What is the value of the district heating energy in the existing scheme?
> (c) How much electricity would be produced in the new scheme and what is its value?
> (d) What is the value of the district heating in the new scheme?
> (e) Is the investment a good one if its capital cost is $500,000?
> ELECTENG 101 examination, 1998

This course had the lowest pass rate of all the Part I courses, followed closely by Materials Science. It was unclear why this was so, particularly as all students were expected to have a background in Physics. One explanation might have been that the marks earned were precise – every ½ mark could be precisely allocated, based on facts or calculations using appropriate formulae and there was no possibility of bluff or guess work in answering the questions. Terminology and concepts such as *"Thevenin's theorem for an arbitrary two-terminal linear system"* could not be linked to "common sense" or logic, or even previous life experience. Calculating the current flowing through resistors was a learned skill. Except for the last question there was no choice in the examination. This was seen by staff as a course in electrical engineering fundamentals and therefore all of the content was examinable and required.

In my view a number of factors may have contributed to the low pass rate: the students' immaturity, a lack of the self-discipline and time management skills needed for them to learn new concepts, terminology and techniques, and the possibility of poor teaching practices. An alarming number of prospective Electrical Engineering students failed this course and it seemed evident that, although "teaching" was occurring, in many cases "learning" was not.

#### *5.3.1.5 Environmental Principles*

Assessment in this course, which was part of the professional development core of the degree, emphasised that engineers working in the areas of sustainability and resource management had the power to "make things happen". Students were introduced to the types of responsibility that engineers would have, such as, setting standards and acceptable levels of contamination, and implementing procedures for consultation and resource management. Engineers were depicted as needing to know "what the numbers are", researching data at both the problem identification and solution stages. The assessment tasks were four research projects each of 1500 words, and a two hour examination. The research projects, done individually, were also used as a tool for teaching students research skills and formal report writing, and a high proportion of the allocated mark was on presentation:

*When I discovered that the marking scheme was 55% format and 45% content I was a little – perturbed is one word for it. Made the last one a bit easier. Laurie, 1st year 1998*

*I guess it was a crash course in report writing Brian, 1st year 1998*

The types of questions used in the examinations made the links between the role of the professional engineer and environmental issues quite explicit, with approximately 80% of the paper focussing on questions like the following, in which quantitative methods were predominant:

> An average person in a developed country such as New Zealand (population 3,618,300) uses 152 kg of paper every year. Seventeen trees are needed to make one tonne of paper and approximately 1000 trees grow per hectare. Each tree weighs an average of 200kg, including roots. Calculate:
> a) the amount of land needed to grow trees for paper for the population of NZ for this year
> b) the efficiency of converting trees to paper
> c) the amount of $CO_2$ released to the atmosphere from the tree debris (C=50% tree debris) wasted in producing the paper needed for the population of NZ this year, assuming that all the carbon becomes $CO_2$
> d) the amount of land required in 20 years to supply paper for one year for the population of NZ assuming it takes 20 years for a tree to grow to harvestable size. Assume population growth remains constant at 1.4% and our consumption per capita remains constant.
>
> Q B7, 1997

Approximately 20% of the paper was in the form of two questions that did not involve mathematics but emphasised opinion, judgement or knowledge of process.

One such question was:

> A meat works tannery's waste discharge entering a river contains heavy metals including cadmium, zinc and nutrients such as nitrogen and phosphorus. Upstream of the tannery is farmland which among other contaminants is leaching DDT into the river. What kind of impacts would there be on organisms in the river? Include in your answer a description of bioaccumulation and biomagnification. QC12, 1997

A range of questions was given in this examination to ensure that students from all specialisations could see relevance. For example, one question required an environmental impact assessment for a hydroelectric dam, another the recommendations for waste management at an appliance manufacturer.

Previous researchers (Cobbin, 1995; Rosser, 1997) as mentioned in Chapter 2, had suggested that female students might be attracted to content that included social and environmental issues. It was noteworthy that in both 1996 and 1998, my analysis of the final marks for this course confirmed a small but significant difference in performance in favour of female students compared with males. (See Appendix 12.)

#### *5.3.1.6 Engineering Design 1*

This course was entirely assessed by on-course assessment, which covered a wide range of skills and abilities. Assessment tasks included: two "design and build" projects done in groups but requiring individual working drawings and a group report, an individual poster and five minute oral presentation on an engineering disaster, a test on drawing skills, and a conceptual design requiring an individual written report. The conceptual design in 1998 required students to design a parking scheme that optimised the number of possible car parking spaces in a new parking building.

Assessment in design strongly reinforced the valuing of skills in understanding engineering drawings, the process from problem brief to design solution, communication skills both written, oral and graphical, and as discussed in an earlier section, the ability to work as a member of a team to a successful conclusion. Jokingly, but with more than a touch of truth, one lecturer commented:

> *…the main thing they learn in Design is that your design has to work, it has to do what it was designed for – it can't be half right* *Diary, Oct 1999*

My analysis of final results did not show any significant differences between male and female achievement in the Design course (See Appendix 12). Despite perceptions that male students were more confident and able than their female peers (discussed in Chapter 6) in Design subjects, I concluded that the range of skills assessed in this course may have had the effect of balancing out any gender differences in individual assessment items.

### 5.3.2 Assessment past first year

After the first year, students entered their chosen discipline and the courses became very focussed, with assessment continuing to play a role in their ongoing enculturation as engineers. My analysis showed that the demarcation between the technical courses and the professional aspects of social and environmental became evident in the assessment tasks. Courses in the later years of all specialisations were focussed on the engineering science, and the norm was for no examination questions to be found that incorporated discussion or opinion on social or environmental issues except in the professional development courses:

> *I wouldn't say it (sustainability) was brought into other areas, it could have been brought into design, I guess a little bit in design we had to consider the effect on the environment of our plant but that was about it actually.* *Sally, $4^{th}$ year C&M 1997*

The program as a whole incorporated the wider community-related responsibilities and understandings recommended in reviews such as the IEAust review. Individual courses however, were quite separate modules that tended to compartmentalise the learning areas.

Where course aims were provided they emphasised the understanding and application of knowledge:

> Aim: To understand the fundamentals and basic principles in the design and operation of heating, ventilating and air-conditioning systems…
> MECHENG 411 handout to students

> Aim: To enable Part II students to study machines and mechanisms and gain a better understanding of how general machinery is designed, functioned and manufactured…
> MECHENG 223 handout to students

This understanding was most commonly demonstrated through the appropriate use of mathematics, continuing the pattern laid in the first year courses:

> *We are trying to give them a basic understanding of processes and we check their understanding through the use of formulae – if they didn't understand the processes they wouldn't know which formula to apply.* *Sstaff10, feedback, Sept 01.*

For the majority of engineering courses 50 – 70% of the assessment marks came from invigilated tests and a three hour examination, which guaranteed an individual, unassisted response. "Open book" examinations were quite common as many lecturers were more concerned with the understanding of the use of formulae than the ability to memorise:

> *I prefer engineering to science, it is often open book, but it is more like you have to understand it and apply it rather than learning all this heaps of stuff*
> *Sally, $4^{th}$ year C&M, 1997*

> *My exams are usually open book, or at least with a page of formulae provided. It is how and when to use them which is important* *Sstaff11, Sept 01*

Even prior to the introduction of the new curriculum, the degree contained a high proportion of on course assessment, in the form of assignments, projects, and tests, sometimes up to 100% in courses such as Design and the final year project. The contribution coursework made to the overall assessment was increased in the new curriculum with its emphasis on project based learning, communication skills and professional development.

Assignments were often open ended problem solving exercises of a larger size and depth than could be covered in a test or examination situation. It was common for the students to be asked to present an answer, often using diagrams, computer applications and mathematics but accompany their answer with a report containing written explanations, and their conclusions and justification of any assumptions or choices made.

> *The assignments give us the chance to get the students to apply their knowledge to situations they might never have thought about, like modelling the heat transfer around a landmine, using an unusual analysis method. The landmine one used spreadsheets in an unusual way… so they are using skills of analysis, application and even sometimes evaluation…* *SStaff10, Sept 01*

For project based assessment, in response to a recognition of good teaching practice and the need for accountability, strict marking schedules were common. The weighting given for content, presentation, and other facets were clearly delineated (as illustrated later in the example for a final year project in 5.3.4).

One of the goals of the new curriculum, as noted earlier in section 5.2.2, was for students to take an increased responsibility for their own learning. In this sense, on-course assessment was intended to provide appropriate opportunities for learning experiences which, with appropriate guidance and feedback, would increase understanding. Students appeared from comments like those below, to recognise on course assessment as a valuable part of the learning process:

> *If you do assignments you definitely learn by that* *Alex, 1st year student 98*

> *…if you have to do problems it sort of gets cemented in your head – you will have a lot more study when the exams come if it hasn't been drummed into you*
> *Laurie, 1st year student 98*

> *I think we are taught this by being given projects that make you think this way as they are very hard to do otherwise – you really learn from the projects*
> *Joshua, 1st year student 98*

Responses outlined later in Chapter 6 however, demonstrated that other unintended behaviours and attitudes also arose.

### 5.3.3 Assessment of group projects

The regulations in the University Assessment Policy regarding group work were:

> *The percentage awarded to group work (where individually assessed) is limited to 20% of the final total. When not individually assessed this limit falls to 10%.*

This requirement for individual assessment was a dilemma for a professional course that wished to emphasise experience and training in group work via project based learning. As one staff member, who had a 4th year elective course that was entirely project based, commented:

> *The university rule that no more than 20% of assessment can come from group projects is an outward sign that teamwork and cooperation is not really desired in this place (the university) …Discrepancy between the rhetoric, what we say we value – teams and cooperation, and the assessment structure which disallows assessing that. These restrictions mean that we do most of our assessment by individual reports.*
>
> *SStaff7, April 2001*

The following examples illustrated attempts to fit in with the regulatory constraints on assessment and yet provide learning experiences that demonstrated a valuing of group and team work.

#### *5.3.3.1 Technology Management Year 4*

This final year elective course taught by the Mechanical Engineering department was designed to introduce contemporary industrial problems and the techniques used to solve them:

> *We used to teach them the tools – but they need to understand the application not just the tools – must run project based learning …Students have had little previous exposure to the tools and theory of management – we throw them in at the deep end really – but I believe it is the only way to teach them this sort of complex stuff so that they understand the issues.* *Sstaff7, April 2001*

Despite the staff who taught the course strongly identifying to the students that this project was a unique cooperative opportunity to work with industry, and that it was expected that they would work in groups, the assessment was based on individually presented reports and an examination:

> *These university restrictions mean that we do most of our assessment by individual reports. …Usually everybody in a group is involved to some extent – usually very transparent division of labour, they collect data on separate parts individually and share results and thinking and then write up an individual report on the same results, project and process.* *Sstaff7 April 2001*

Each student was requested to provide a one page summary of their personal view regarding the use of project based learning in teams and the effectiveness of their team – but the staff chose to use this to stimulate students' thinking and aid future course refinement and the summary was not part of the assessment process. The staff saw the thinking and learning around the skills and processes of teamwork as valuable, but to form some objective assessment from these very subjective comments was "*too hard*" and therefore not included.

#### *5.3.3.2 Design 1 course*

Attempts to demonstrate to Part 1 students that skills in working as a team were valued, by including a component of self and peer assessment in the overall assessment of their second design and build project, received a mixed reception from students in a trial done in September 1998. Students were asked to score themselves and the others in their team on a scale of 0 to 6 on categories such as participation in group meetings, carrying out allocated tasks, contribution of ideas and suggestions, overall contribution to the project. The group scores for each person were then averaged out and the mark for the project divided up proportionately. For example, one group had one person that they all identified as having contributed very little (0 or 1) and in that group the mark for the project was allocated as 100%, 98%, 100% and 19%. After discussion with the tutors involved in this trial we identified a range of issues around the use of self and peer assessment including:

1. Roles in the group were not clear cut
2. There was evidence of collusion and trivialising of the assessment in some groups where each member of the group gave the others the same scores
3. Students found it difficult to assess the relative worth of writing the report, organising all the meetings, or having the ideas for the design.
4. Students did not know each other well in their first year, and ethnic and cultural differences complicated group dynamics.

The majority of the students were still quite immature and inexperienced with the level of critical thinking required. Their lack of comfort with this form of assessment was illustrated by the following comments:

*The assessment thing was not good – you are working together, working like group – all trying – don't know how much to give to all – gave same mark to all people. The woman had no ideas, but she did the report and the calculations.*

*Jaimie, 1st year student 1998*

*For the assessment – I give them all 5 or 6 marks (6 was top). I put myself in their place, it wouldn't be nice to put them lower. All studying – value each contributing together, why kill off each other. Didn't give myself more …doing the report is equal to doing the building. They try, maybe they have family problems…*

*Simon, 1st year student 1998*

*Group projects are very difficult to assess. What happens behind the scenes cannot be conveyed with a few numbers on the paper. John, 1st year student 1998*

I suspected the crux of the problem was identified in John's comment, namely, attempting to quantitatively assess the contributions in group work. Visible results such as diagrams, reports or models could not accurately portray group dynamics. At this first year level, staff said that they were reasonably content that just "getting a model that worked" was a successful enough outcome, with the main point of the peer and self assessment exercise being to emphasise that skills in team work were valued.

Despite a variety of methods being tried, no solution appeared to have been found that was felt to be entirely fair and equitable for assessment of individual contributions in group projects, although both staff and students believed the value in learning to work in diverse teams was worth minor inequities:

*…you might have had a weaker person in that group yet everyone in the group ended up getting the same mark, and that was a bit unfair but you did that because you know that the marks were going to be a bit unfair but you were teaching the students to work together as a team. Maybe you sacrifice being fair on the grades to encourage the team work. Chloe, 4th year Mech 1996*

### 5.3.4 Final year projects

The curricula for all departments except Civil Engineering contained a compulsory final year research project which was done either individually or in pairs. These differed slightly in approach between departments but were viewed by both staff and students as the "*Jewel in the Crown*" (SStaff6, March 2000) of the engineering degree. The project carried 50% more points than a normal course, and brought together all the engineering skills of investigation, analysis, design, implementation, and presentation of results that had been acquired over the four year degree.

The project handouts for the final year project given to the Electrical and Electronic Engineering students described the range of skills required:

> The Part 4 project is a learning exercise in which the student tackles a significant problem requiring independent thought and action in a situation not too different from many that might be encountered in subsequent professional life …The student will need to draw upon a good level of theoretical knowledge and skills acquired so far in the degree and extend these in many respects. A survey of the field in which the problem lays and of alternative approaches to the problem will precede detailed work on a solution. The problem may require the design of equipment to carry out some specific task; it may be experimental in the sense of investigating phenomena or the behaviour of complex equipment; it may require the computer analysis and simulation of an engineering system or it may involve elements of all three of the preceding activities. In each case the proposed solution should be thoroughly tested and evaluated to determine its adequacy…
> A professional report that adequately covers all aspects of the investigation is a key objective of the project and will be assessed accordingly …In addition students will be required to give a demonstration of their work as well as a formal seminar to staff and students…. Project Handbook ELECTENG 401

The allocation of marks in assessment of the projects reflected the valuing of a wide range of technical, communication and professional competencies. Electrical Engineering allocated marks for their project based on the following schedule:

| | | |
|---|---|---|
| Interim report | research skills plus report writing | 10 % |
| Project implementation | assessed the degree of application of the student to the project and the quality of the work undertaken | 30 % |
| Demonstration | oral communication plus poster | 7.5 % |
| Seminar | oral presentation | 7.5 % |
| Final Report | Report writing | 45 % |

Staff and students recognised that, over the duration of the project, considerable personal growth for the students occurred:

> *The final year project students who work with me, many admit the beginning was a bit daunting. They realise by the end that the technical achievement is actually secondary to their personal development.* *SStaff6, March 2000*

For the students, there were mixed emotions and experiences, but a very real sense of achievement and understanding of what it meant to be an engineer was evident in comments such as these:

> *By doing this project I learn how to learn and I finally find out actually engineering life is not as bad as what I thought – after project my attitude has really changed.*
> *Stella, 4th year E&E, 1996*

> *The thing I liked most would have to be the project because of the satisfaction you got out at the end. You are working quite closely with your supervisor and with a partner so yeah …oral presentation was a bit nervewracking at first but we were fine …I am still quite interested in research, I got hooked in my fourth year project…*
> *Amy, 4th year E&E, 1996*

## 5.4 Rewards – for good teaching

If excellence in teaching was valued, as espoused in the university's mission statement (Ref 4.1), and was indeed part of the culture, then arguably, that valuing would need to be embedded as a cultural norm in the reality of university practices. Within the cultural framework I have proposed for this analysis, reward systems such as public recognition and promotion could be viewed by staff as the manifestations of the espoused valuing of teaching excellence, in the same way as (Ref section 5.3), good grades in assessment led students to understandings of what knowledge and skills were valued in their learning.

### 5.4.1 Teaching awards

The School of Engineering had a tradition of offering Teaching Awards for many years, "*long before this became university wide".* There was considerable pride in the practice of offering this Award and one of the originators of the Award asserted that it "*demonstrated that good teaching was valued by the Faculty*" (Diary, April 1999). In practice, students were surveyed and asked to rank the top five academic staff who had lectured them in that year. Photos of each lecturer were provided and the survey was preceded by the following statement which clearly defined what was valued in teaching:

**What is the BEST? It is NOT necessarily the most POPULAR!!**

> We suggest that you vote for the teachers who have presented the subject matter in a well ordered and structured manner with clarity and relevance; those who have best helped you grasp the ideas and principles, who have given you clear insights, knowledge and problem solving ability to master the subject.

A mathematical formula, which had been refined over many years, ranked the academic staff taking account of large and small class sizes, total students taught and contact hours. The award was recognised by a certificate presented at a Faculty meeting, but had no financial value. The top 20 teachers' names were published on the Engineering website. The top teacher was put forward as the School of Engineering nominee for a University Distinguished Teacher award which carried with it a monetary prize ($5000), a medal and a formal ceremony of recognition. Whereas the central University award system required the provision of a "Teaching Portfolio" detailing innovation, student evaluations, curriculum development, examples of assessment etc, the Engineering Teaching Award was based solely on student evaluations, and as such, some staff perceived the system as flawed:

> *Noticeable the people who get the Distinguished Teaching Awards are the people who write slowly on the board, and give beautiful handouts with everything in it… if they have to take notes like in my subject…* *Sstaff3, Sept 00*

> *I have always thought it was more of a popularity award than anything else.*
> *Jstaff1, Jan 98*

These perceptions, combined with my own observations, led to my conclusion that despite its good intentions, the award did little to encourage staff towards innovation, further professional development, or critique of their own teaching methods.

### 5.4.2 Promotion

The University policy on promotion for academic staff required applicants to provide evidence of performance in three areas, Teaching, Research and service contributions (the latter either within the university or community). Promotion depended on applicants meeting specified criteria of Satisfactory, Merit or Excellent performance in these areas. Quoting the *"Academic Grades – Standards and Criteria*" HR Policy document available to all staff on the web, *"a candidate for promotion must have reached a satisfactory (or in the case of Associate Professor – merit) level of performance consistent with his or her grade of appointment in each of the three broad areas for promotion. In order to be promoted the candidate must in addition demonstrate merit (for promotion to Senior Lecturer), excellence (for promotion to Senior Lecturer above the bar) and distinction (for promotion to Associate Professor) in at least one of the three broad areas".* It was expected that the Teaching Profile would be drawn from the staff member's teaching Portfolio, including papers taught, and graduate students supervised, a summary of evaluations of teaching, a summary of evaluations of courses and a summary of teaching improvements, curriculum development, course improvements and professional development in teaching. This policy implied that, for the majority of academic promotions, teaching need only be satisfactory if the candidate is seeking promotion on the basis of his or her Research profile.

Despite the espoused value of teaching expressed in mission statements, objectives in strategic plans (quoted in section 4.1) and the best intentions of a promotion policy which provided opportunity for promotion based on teaching profile, no staff member at any level expressed confidence that this was current practice. One senior staff member identified that "scholarship" as applied to teaching, rather than just good practice, was what was needed, if teaching was to have the same status as research:

> *Scholarship could be manifest in many forms, research, consulting, novel design, engineering education …my argument has been that teaching is a perfectly legitimate scholarly activity but not in isolation like – need to go to engineering education conferences – do that by developing ideas and then allowing them to be challenged. Your thoughts are challenged by others …School would be a better place if we had some people whose research focus was engineering education.* *SStaff1, Oct 97*

Few staff, approximately 3% annually, attended conferences devoted to Engineering Education – and the limited available conference funding was prioritised for technical conferences. Little educational research was therefore completed and no more than one paper per year (in total), at the time of this research, was published in an international educational journal.

The promotion criteria, referred to previously, included equity considerations. Staff could, but were not compelled to, include information that demonstrated an understanding not only of possible gender and ethnic differences, but also of attempts to ensure that content and curricula took note of and valued a diversity of contributions and understandings. As indicated in section 5.2.10, my discussions with staff members did not yield any evidence that teaching content, style or assessment had specifically targeted or acknowledged different learning styles, contributions or understandings.

My observation of classes and discussions with academic staff provided ample evidence, however, that the majority of staff attempted to teach in a quality manner and put considerable thought and effort into the content of their lectures. Time was spent on the preparation and definition of appropriate projects and assessment methods, but there seemed to be a shared belief that this commitment was for personal satisfaction and academic integrity rather than for reward or promotion purposes:

> *…they say teaching is important but it isn't, there is no one to say you are doing a shitty job, I put a lot of effort into what I do, and I am a reasonable teacher and yet it doesn't matter, it doesn't matter at all.* *JStaff2, Oct 97*

The following quotes indicated a mismatch between the espoused values of mission statements and promotion criteria and the shared understandings of all levels of staff about the relative importance of teaching and research:

> *The most important thing is to publish papers, that is what will get you promoted fastest. I guess just in terms of some sort of personal satisfaction and staying sane doing at least a reasonable job of teaching is necessary but publishing papers is what gets you up the tree fastest* *SStaff2, Jan 98*

> *Well, there are clearly rules in the academic game and the rules have always been up till now, publish like mad and ignore everything else and that is a culture which hopefully is changing but I will really believe that it has changed when we start to see some evidence of it changing and we start seeing people being recognised for outstanding teaching or recognised for outstanding administrative capability.*
> *HOD1, Jan 98*

> *I still feel for the students because some of us are shocking lecturers and basically the university employs you because of your research ability not on how good a lecturer you are…* *JStaff1, Jan 98*

## 5.5 Events

A variety of events occurred in the case study institution and I have included them in this chapter as practices. The events which have the most cultural significance are those which might be deemed traditional, or regularly occurring events of long standing. For these events the interconnectedness of practices and behaviours is very evident. Events could be merely phenomena, but for some events, shared behaviours and tacit understandings gave them cultural significance. I have included in my discussion below those events, and the responses to those events, which I believe provide information directly relevant to my Research questions and illustrate the ways in which shared values and norms are manifested.

### 5.5.1 Orientation

Orientation events for new students provided an ideal opportunity for introducing new students to the day-to-day practices and behaviours that manifested the underlying cultural values and norms – the beginnings of their enculturation.

The orientation event took place on the first morning of the first day of the Semester, with all first year students assembled in the main hall of the Recreation Centre, located close to the School of Engineering. Changes to the event were made in later years but the information provided here relates to the 1998 orientation event, which was the first one of its kind.

The top priority in organising the 1998 event was the speedy and effective transfer of necessary administrative information regarding timetabling, and class organisation, after a city-wide two week power crisis had caused a one week delay in the start of semester, with associated organisational problems. Several staff, including the Associate Dean Undergraduate, recognised that the much larger number of students resulting from the change in selection criteria, might cause the close-knit class spirit of engineering to be under threat. An orientation event in which all the lecture streams were brought together was suggested as a way of integrating the group. The Associate Dean discussed with me his perception that the transition to university life appeared to be difficult for many students, and with the compressed semester system, delays in the initial weeks could severely affect academic outcomes and the personal adaptation of students. Combining these concerns, the program for the morning was therefore a mix of administrative detail, motivational speakers and information about support services and faculty expectations.

Students arrived to loud pop music and were asked to write their first name on a sticky label and collect a Handbook and other printed material. Seating was rudimentary with many students sitting on mats on the floor and an air of "organised chaos" initially prevailed. Formal proceedings started with a welcome from the Dean of Engineering. His was a very personal perspective as he extolled the virtue of the students' choice to do engineering, his own career having proved that a degree in engineering opened many doors, in industry, the corporate world and in academia or research. A professor who had served on the Board of IPENZ then welcomed the students to the engineering profession. He emphasised that this day was the first step on the pathway to a profession – and that this implied not just an education leading to an occupation, but a professional responsibility to society that came before employer and self. He reminded the students of the self-policing that would be needed because others might not have the specialist knowledge and the need for integrity:

> *It is too often seen as simply a "career". But it is much more than that. A notable characteristic is that one's first responsibility is to others. Further, because of the high level of expertise involved, it is usually not possible for others outside the profession to police a true professional. Hence, the most important requirement of a true professional is integrity. This will be expected of you.* *March, 1998*

The emphasis was continually being made that the students now not only had entry to a select group, they belonged to a wider, respected community.

After some administrative details were dealt with, the Associate Dean Undergraduate then made specific comments regarding the degree program and expectations.
His words to the students included:

> *A degree is the key to your future. And an engineering degree is a very valuable, and particularly versatile, key. It is far better that a simple BSc degree. Appreciate that your degree is not to simply something that allows you to earn a great income – it is the pathway to a satisfying career …Realise that most people are known/recognised by their occupation.* *March, 1998*

These overt statements of loyalty and bias "*far better than a BSc*" appeared to lay the foundations for a sense of superiority and pride in their identity as engineers.

The Associate Dean spoke also of his role in interviewing students who were not making good progress and the relationship between work effort and grades:

> *Grades are proportional to Work. You will work harder than you ever did at school, even if you are a bright student. The engineering workload is viewed as harder than most/any other degree.*
> *March, 1998*

The belief that this degree was "hard" was being mentioned early.

Whilst the Associate Dean spoke of the need for integrity and the unacceptability of "cheating" or inappropriate co-operation, he stressed the need for working with others:

> *…under the appropriate circumstances, co-operation is not only acceptable – it is essential.*

He reminded students that all subjects in the Part 1 course were to be viewed as important:

> *…you have no idea of what you need to know. Need to appreciate you are here not to learn "engineering" but to learn to think, and the "irrelevant" subjects probably make the greatest contribution to this.*

My assumption was that this comment probably referred to the breadth of subjects covered in Part 1 and the Associate Dean's awareness that some of the students thought subjects such as Environmental Principles were irrelevant.

Representatives from Student Health, Counselling and the Student Learning Centre were all introduced, as well as other sources of student welfare support on campus. Putting a face to the names was seen as essential, even if only briefly.

The Engineering student society representatives presented the face of the traditional engineer – *" we have lots of events, parties with free booze*". More than one first year student remarked that these comments were inappropriate for the majority of the very diverse group of first year students:

> *…that guy from AUES – I thought he went down like a lead balloon – considering the diversity of this group* *Brian, 1st year, 1998*

> *…they talked about – come and be blokes and mates – I don't think many of the first years can take to that* *Angus, 1st year 1998*

Icebreaking and mingling games were attempted, including a scavenger hunt – and although my immediate perception was that these were not a great success, the hubbub and chatter seemed to imply that their subtler objective, which was to cause the students to mix and mingle and talk to each other, was perhaps achieved:

> *You got all those people and they didn't know anything about each other but they were all like trying to get on, and find out things about each other.*
> *Michelle, 1st year 1998*

> *I didn't know anyone in engineering at all, I knew no one and I came in on the first day thinking I would come and I would have to get to know someone soon and on the first day I must have met about 25 friends. Every time I sat down next to someone I would talk to them so by the next day, even if I didn't remember their name I would remember their face.* *Barbara, 1st year 1998*

Senior students and staff were present and mingled with the students over morning tea and lunch (which was a free barbecue in the courtyard of the School of Engineering). No formal classes were held that day and students were encouraged to use the afternoon to acquaint themselves with classroom venues, finalise timetables and take part in other on-campus orientation activities.

### 5.5.2 Faculty meetings

Faculty meetings were held four or five times a year and were the formal gathering of academic staff members, and representatives of technical and general staff of the Faculty of Engineering. The function of Faculty meetings included the approval of degree regulations and strategic planning for the Faculty as a whole. Faculty meetings were a forum for debate and discussion of matters such as new building plans, proposals to move the Faculty to another site, the appropriate balance of Project based learning within the degree, and other such future directions for the Faculty.

Compared to my experience of other faculties on the campus, a higher proportion (approximately 70-80%) of staff attended the Engineering Faculty meetings. All academic staff were automatically members, but representatives of the technical and general staff were also members, with other staff welcome and able to attend as observers.  The Dean chaired these meetings and, whilst styles differed, the atmosphere was never dictatorial, although the Dean's position as the leader of the Faculty was quite evident. I did not observe a formal vote ever taken. Consensus was usually sought, and in my experience a show of hands was usually sufficient.

An open and frank atmosphere was encouraged. My field notes and observations over a period of ten years however, demonstrated that the same regular voices (approximately 10 to 15 out of 100 attendees) were heard at each and every faculty meeting. Many young, or new staff (both male and female) took a very long time to speak out and some long standing staff were never heard. It was rare for one of the few women staff to speak at a Faculty meeting, but their contributions were as well received as those of their male peers. Efforts were made by the current Dean to encourage a wider range of voices by asking for the presentation of departmental feedback on topical issues to be given by a staff member other than the Head of Department.

It is not appropriate in the context of this case study which aims to focus on the culture of engineering education, rather than a close study of an organisational culture, to spend too much time on the behaviours and practices of these meetings. However, a number of practices relevant to cultural norms were observed:

- First names were often used rather than titles, demonstrating the non-hierarchical nature of interactions between staff;
- Disagreement and counter opinions were often evident:

> *Faculty meetings seem to involve pretty frank discussions. You can disagree, and some people hold quite opposing views, without any seeming repercussions which would be*

*unusual in some organisations. There seems to be an attitude of – well I disagree but I will go along with what is decided by the majority* *JStaff6, Jan 2000*

Disagreements rarely reached the stage of heated words, although I noted that vigorous and sometimes heated discussions had often taken place in private before the meeting. Some teasing or hazing of fellow staff expressing contrary or controversial points of view occurred but it was relatively inoffensive and similar to the teasing between family members. This usually only occurred with staff who knew each other well, and I never observed it to take place with newcomers.

- A strong "them" (any other part of the University) and "us" (the Faculty of Engineering) feeling was evident in many of the discussions.

An example was the meeting to discuss proposals by the central administration to move Engineering to a less central site at which comments such as "*we should govern ourselves – either be given it or take it*" and "*how can we order our own destiny, maybe we should secede from the University"* (May, 1997*)* were a reflection of the tone of the meeting. I recognised these comments as bravado and jest, but reflective of the cohesive "separateness" felt by many of the staff.

### 5.5.3 Staff social functions

Staff social functions involving all staff were few and far between, other than the Christmas barbecue and retirement functions. The tradition of all staff mixing together was spoken of, especially by long serving staff who viewed the Christmas barbecue as the nearest thing to a traditional event that the School held. All staff were invited and a high proportion attended. A tarpaulin was erected as a shade (or rain) protection over the car park area between two buildings, tables and chairs were taken from classrooms and workshops, music was provided by a relative of a staff member, and the technical staff provided the traditional Kiwi BBQ of sausages and steak plus salad and fresh bread. My perception in the late 1990s, at the time of this study, was that the appropriateness of the event and the enthusiasm for it was dying. It seemed a hangover from a time when the School of Engineering was an almost all male institution that saw a social function as 'a beer, a sausage and a piece of bread'. In theory, the opportunity was there for all staff to mix and mingle and celebrate the year together, but the groups of technicians, secretarial and academic staff tended to stay in their groups.

Social functions at departmental level had become less frequent in the late 1990s than in earlier years. Reasons given for the lack of social interaction ranged from; the departure of a staff member who had previously organised them, the current extreme pressures on time – staff working 12 hours a day did not feel the desire to further socialise with colleagues, to the possible over-familiarity of staff in some departments who had worked together for more than 20 years:

> *We haven't had one with just staff and their partners. I think we know each other and our partners reasonably well. I know all the names of all the partners of all staff, yeah, I might not have gone out with just them but at some stage we have gone out together or subgroups… Individual staff members with large research groups they do have their own social things.* *HOD2, Jan 1998*

The cohesion spoken of with pride on academic matters was therefore not manifested in social interactions outside of the working life except for small groups who played golf, jogged or went tramping together.

### 5.5.4 Staff-student events

Several departments attempted to organise social functions that involved staff and students, but they were not high priority and in most departments were linked to specific celebrations of academic achievements:

> *We hold a picnic for all the students at the beginning of the year. A dinner near the end of the year primarily for the finishing students and we hold a smaller function for graduate students, and a party for the graduands at Graduation ceremony.*
> *SStaff2 Jan 1998*

The Final Year Project presentations were used as a celebration of degree completion by several departments and together with Graduation ceremonies, which took place six months later, served as "Rites of Passage". Staff greeted students at both these events as new members of the profession and laughed and joked with them as equals or colleagues. The "family" feeling was particularly evident at Graduation ceremonies, as the lecturers joined with the families of the graduands in pride and celebration and it was clear that in many cases staff had formed close connections with their students.

Both Civil Engineering and Engineering Science held field trips of several days near the beginning of the year. These provided opportunities for informal staff – student contact:

> *We visit some industrial plant or companies, in a bus. Three or four staff go along with the students. We do a couple of days of that and perhaps half a day doing something outdoorsy like a raft trip or a short hike …The social interaction is usually pretty good – have most meals together – usually the students do a bit of drinking but it is not real bad drinking in terms of getting totally drunk or anything.* *SStaff2, Jan 1998*

As a department with class size rarely above 40, field trips for Engineering Science were felt to be administratively possible. The Civil Engineering course required a field trip for practical experience in courses such as Surveying, so, despite a larger class size of around 80 students, the trips were continued. Departments such as Electrical Engineering, under severe staffing constraints and with much larger class sizes of over 100, did not organise field trips except for short excursions lasting a couple of hours.

### 5.5.5 Student events

There was a long history of student social activities within the School of Engineering, but the majority of that history lived in the memories of former students, and was the stuff of myth and legend rather than commemorated in visible or tangible representations.

The social and sporting activities of the School were predominantly organised by the Engineering Students Society (AUES), which had, because of some clever manipulation of student politics in the mid 1980s, gained an ongoing, substantial supply of funding from compulsory student fees. The constitutional aim of this Society was to provide social activities for their fellow engineering students and "have fun".

In 1996/97 AUES held the following events: Ball, Dinner, Pub Crawl, Champagne Breakfast, several Steins, Wine and Cheese careers evening, and various sporting fixtures such as a team in the Round the Bays Fun Run. Each of these functions involved the consumption of heavily subsidised alcohol in one form or another. The officers of AUES were volunteers elected each year, usually in their third or final year, and were rarely part of the executive for more than a year or two. The executive were predominantly male and European, although in the 1990s there had been two female presidents and several female members of the executive committee. Other than a Maori president and executive member, other ethnic groups were not represented on the executive. For many years, this group had determined which social and sporting activities would occur and to what extent they would be financially subsidised. Evidence from the number of students attending functions, and voting in the elections demonstrated that AUES had the support of less than half the student body, but they were the publicly visible social face of engineering and their activities were seen as representative of the engineering culture:

> *I think it (AUES) is responsible for maintaining the culture of engineering – well it has been – and I am not sure if everyone quite appreciates how much effect they have on people's perception of engineering.* *Brett, 4th year E&E, 1997*

> *Why has Engineering been stuck with a neanderthal stereotype? …simply put our stigma has been due to the 'blokes' being the most visual part of the Engineering school…* *'Enginuity' (student magazine), April 1997*

> *The engineering society – a lot of the events they organise don't have the patronage across the board that I think they should have – they are still organising events for this stereotypical drinking engineer and that is the way it has panned out – but they are the one who are motivated to get off their butt and do it* *Richard, 4th year E&E, 1997*

Excessive alcohol consumption and being able to "take it" were glorified in the Engineering Society events, and these practices and behaviours have been closely linked (Phillips, 1996) to a dominant New Zealand model of masculinity. Terms such as the "blokes" or the "lads" often used to describe the stereotypical engineer were themselves masculine terms:

> *A huge generalisation would be to break the school up into "blokes" (which does include some women) and "academic students". Blokes – more like the stereotypical engineer. This is a very small group making a lot of noise.* *Trish, 3rd year Civil 1997*

Some female students were very involved in the AUES social activities. They took part in pub crawls, got drunk, and organised events, but they were rarely involved in the most excessive of activities e.g. the Naked Skull. Although these young women were clearly happy to be considered "one of the guys", they did not consider themselves masculine and did not equate their behaviour as signifying masculinity or femininity – merely their right to exert free choice and be part of the group.

The graduating students interviewed and surveyed in 1997 had very mixed and somewhat divided views on the social activities organised by AUES. About two thirds of the male students questioned had been to an AUES event and less than half of the female students. For some, these activities were the highlight of their time at university and provided lifelong friendships and a balance from study that "kept me sane". A large number of both male and female students cited the need for a shift away from the hard drinking, boozy stereotype of engineer as an aspect of the Engineering school needing improving:

> *I organised the Round the Bays run this year and I was quite surprised at the cross section that did that – we organised an after run function and a T shirt and a meeting before hand. I think that went quite well.* *Terri, 4th year Mech 1996*

> *Anything organised by AUES I stayed well away from. I don't drink so I found anything they ran quite alienating. I went to one beer Stein, possibly my last year – it was quite an experience – especially since I was sober. I can hang out with drunk people without much trouble most of the time – but this was something else*
> *Rose, new graduate, Eng Sci 1997*

> *I couldn't have done without social activities. The harder I work in my studies the more I need and enjoy socialising. Loved my University years.*
> *Questionnaire M12, 1997*

> *Social activities the best on campus* *Questionnaire M2, 1997*

> *Events organised by the Engineering society are for a select group only, many students do not attend social events because they are for male students who drink*
> *Questionnaire F4, 1997*

The data collection for this research took place from 1996 to the end of 1999, and during this period the student society was attempting to take account of: a more diverse student body in terms of ethnicity and gender, the differing priorities caused by increased tuition fees and the impending threat of voluntary membership (which was expected to cut funding significantly). The more formal functions such as the Annual Ball and Dinner were held in up-market venues, and academic staff were encouraged to attend by the Dean who, as stated previously (Ref 4.1) saw these events as a valuable part of student life. In a conference paper that I co-wrote with a fourth year student we acknowledged that:

> *…the activities of AUES affected every engineering student, either because they were flourishing at the social occasions or because they were sheltering from the stereotypes thrown at them from all sectors of the university as a result of those activities.*
> *Hansen & Godfrey, 1997*

AUES was presented in our paper (Hansen & Godfrey, 1997) as trying to perpetuate the traditional engineering culture, which was increasingly becoming less relevant to the current body of students.

A shift to a 12 week semester in 1996 had heralded much tighter time constraints for on-course assessment and students were increasingly placing assignment deadlines before social activities. For me, the most telling example of this was in 1998, when I saw the AUES ex-president, the archetypal "bloke" and promoter of the engineering "play hard – work hard ethic", returning early from the pub crawl. When questioned he replied:

> *I've got an assignment to hand in tomorrow and I can't afford to come back next semester, it is time I got out of here* *Diary, May, 1998*

As I mentioned earlier in Chapter 4, the composition of the student body had changed rapidly in the 1990s and, in 1998, 50% of the first year students had lived in New Zealand less than 5 years. For many of these students the social activities of AUES were not relevant or desirable, and indeed they viewed them as socially unacceptable:

> *Yes I know that reputation of engineering, I don't expect it to go for long. There are quite a few Asians around and Asians don't normally drink … People who immigrate are normally the people with money …and you wouldn't earn money if you were a bummer who drinks all the time. So you wouldn't expect people who come here from other countries to be of the lower social level.* *Alex, 1st year 1998*

Learning about a culture, as explained throughout this study, involves passing on to new members knowledge of accepted practices and behaviours. If the "traditional" social activities and practices were to continue, mechanisms of "handing on" that knowledge were required. For first year students, their first introduction after orientation to engineering social activities was the First Year party organised by the senior students on AUES. In 1998, this was held in an empty warehouse close to campus, with a disk jockey providing music, pizzas delivered at various stages of the night, and accompanied by the usual plentiful supply of subsidised beer (orange juice was also provided):

> *Yeah, I think that engineering exec contribute to that spirit. I mean our first year hooley, it was free entry, heaps of pizzas and drinks and stuff, and it was just for first years… And we had the senior people in the school leading the way and encouraging these social activities as well.* *Shelley, 1st year 1998*

Despite the efforts of their senior colleagues to enculturate them into the drinking culture, the majority of the first year students I had interviewed, both New Zealand born and non-New Zealand born, preferred opportunities to mix socially with their classmates and engineering peers when alcohol consumption was not the prime focus:

> *When we went as a group along to the dinner, that was quite different. It wasn't such an alcohol obsessed occasion – you were going there to have fun and there happened to be alcohol, rather than going along because there was alcohol and any fun would come from the alcohol.* *Rebecca, 1st year 1998*

Female students commonly protested that "*we were treated no different*" but social events created situations where they appeared to feel a tension between wanting to be part of the group and identify as engineers, and recognising that they were “women” – sexual beings with all that that entailed. When alcohol was present they perceived a need for a level of caution:

> *I didn’t go to the paddock party because I was a female and I didn’t like the idea of going out to a paddock where there was just copious amounts of beer being drunk and a bus that comes back in the morning in case you don’t quite make it home and you don’t know where the paddock is… I just thought, No, could be a bit of trouble so…*
>
> *Michelle, 1st year 1998*

> *The only time being a girl is a bit of an issue is when you go to these things and there are all these drunk guys.* *Shelley, 1st year 1998*

The increased ethnic diversity of the student body had resulted in some ethnic groups having large enough numbers to cluster as social groupings, either specifically as groups of engineering students such as the Hong Kong Engineering Students Association, or as campus wide groups such as the Singaporean and Malaysian Students Associations.

Maori and Polynesian students (particularly male students) often joined in AUES activities with energy and enthusiasm, but found extra support and a sense of identity in the social activities organised by their own group, SPIES (South Pacific Islands Engineering Students):

> *SPIES was good, it provided a feeling of community – a family in the engineering school because normally you would go across the road and join the Samoan Association… Because engineering school was unique in its workload and its stress levels, we did not have that time to play. In SPIES we were in the same boat and had the same problems, so we had our own group and formed our own identity.*
>
> *Samuel, new graduate Civil 1998*

The Women in Engineering Network, (WEN) open to all female students, held a series of lunches, engineering site visits and social activities such as kayak trips, tramping and an Annual Dinner. Some female students were uncomfortable with a women-only social group, and saw WEN functions as divisive and implying weakness and a need for support. Others welcomed the opportunity to share experiences and friendship. There was also a small group of female students, usually non-New Zealand born, who were not able for family or cultural reasons to attend mixed-sex events and for these students WEN activities provided a welcome opportunity to socialise with their peers:

> *I think it is a great chance for women to meet women in other years and other disciplines. That whole 'it's not what you know but who you know thing'. It may not be the activity itself that matters but all the side conversations and chance meetings between the students. It's also refreshing to see a bunch of women with the same interests in one place* *Rose, new graduate Eng Sci 1997*

Female only social activities, such as the lunches which often had complimentary pizzas, caused comment from male students who appeared to think they were missing out on something, or could not see why female students should want to meet separately. Geetha's comment demonstrated a perception that she had to justify wanting to attend a female only function:

> *…they always said "But that's not fair, how come you guys get to do all these things and we are never involved", I don't think I ever gave them a straight answer for that because I couldn't* *Geetha, 4th year E&E 1996*

Some male students did see a need for such events:

> *I thought it was a really good idea, I know some of the guys thought it was a stupid or whatever but that is bit ignorant, a bit of a knee jerk reaction, oh it is just for girls that is sexist kind of thing. I think it is good especially when they are a minority in a department.* *Brett, 4th year E&E, 1997*

but others were more negative:

> *…they should not be treated any different to males. If they want equal opportunities they must be treated the same.* *Questionnaire M21, 1997*

Other than the Ball and Dinner, mentioned previously, the most successful social integration of students across gender and ethnic boundaries, that I saw, had been sporting and social events organised by women students. These ensured inclusive teams, and activities, for example, an indoor basketball tournament with teams of five which had to include at least two members of each sex on the court at any time. The wine and cheese careers evening, another well patronised event, was initiated in 1997 by female members of AUES, supported by WEN members, who ensured a sophisticated and professional presentation.

## 5.6 Interaction with the Profession

In the 1970s and even into the 1980s it was not uncommon for staff with professional experience, to have been hired without a research background or PhD and several were still teaching in the late 1990s. By the time of my study in the late 1990s, professional qualifications were seen as desirable but not a replacement for the academic PhD. As a result, a decreasing number of the staff had industry or professional experience. However, the School maintained and encouraged strong links with industry and the profession in both research and teaching. In addition to the requirements laid down by IPENZ for professional accreditation, several departments used Industry Advisory Boards to ensure that all courses were relevant and meeting the current needs of the profession:

> *I also like the fact that there is and has been from the top down in this university an encouragement to work with industry and to do things that have practical significance and practical reality and I like that. I am that sort of person. I don't like the attitude of the (…) department for example where if you once worked for industry you have soiled your hands and can't get ahead…* *HOD1, January 1998*

Industrial support was also demonstrated by the three academic positions fully funded from industry, and industry sponsored research at postgraduate level. In many cases, fourth year projects were funded by industry and projects suitable for Design classes were often developed in conjunction with the industry contacts made by research groups or Professional Advisory boards. Projects such as those described in earlier sections required close interaction and co-operation with the relevant industry to ensure that realistic tasks were used. At student level, the practical, work experience component of the degree, which required at least 800 hours from each student prior to graduation, ensured every student had some contact with the profession. I saw these strong links with industry and the profession as both valued and a cultural norm within the School.

## 5.7 Interaction with academia

The physical isolation spoken of in Chapter 4 (Section 4.4.1) resulted in a perceived isolation or separateness of engineering from the rest of the campus. This was added to by what I observed also as an intellectual isolation:

> *We have had this isolationist culture anyway...engineers have never been noted in this century for being liberal broadminded Renaissance people anyway, they have been people working within a pretty narrow framework of reference, some well read but some sound arrogant when really trying to cover up…* *Sstaff3, Sept 00*

> *We have a superior view, we see ourselves as superior. We see ourselves as achieving an end product that adds value, and it is true that we do. Engineers have been very good at using physical science… "the chemists, all they do is mix a few things together…" … that is a part of the culture* *HOD1, Jan 1998*

Although there were individual research groups who had links with the medical school, management studies and some science departments, they were relatively few in number compared to the interdepartmental co-operation within engineering. In a feedback seminar (October, 1998) part way through this research, I asked staff members to position the Faculty of Engineering and other faculties within the wider University culture, using a Venn diagram approach. Almost unanimously each academic present (n=37) produced a diagram similar to Figure 5.5.

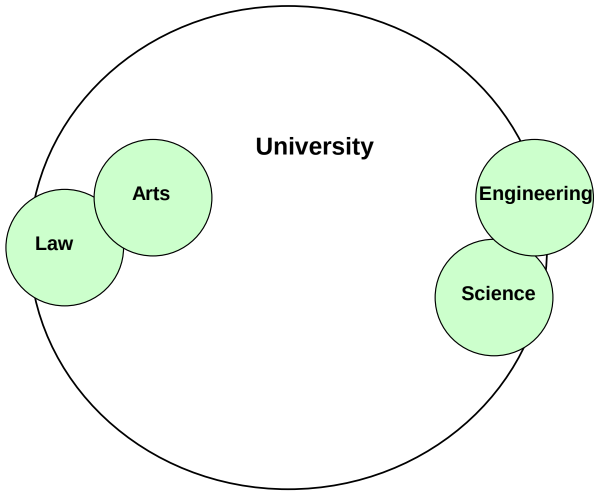



Figure 5.5 Position of Engineering and other disciplines within the University Culture

The sense of separateness seemed to arise partly from a belief that engineers were better problem solvers than anyone else on campus and evidenced itself in comments such as those in section 5.5.2, but also in suggestions that the central administration was inefficient and "*we would be better to do things ourselves*", including "*running our own library, doing our own marketing and fundraising, and examination timetabling*":

> *The current claim from my colleagues for this school to be independent from the rest of university…I have not experienced at other universities where engineering schools are an integrated part of the university …culture that to some extent comes from our history and from the profession and our own image of ourselves.* *Sstaff1, Oct 97*

This strong sense of identity was also linked to a perception that the engineering degree was "harder" and more worthwhile, apparent in comments such as this one:

> *I think we think it (the BE) is more demanding and a harder degree and more useful in terms of getting a job …probably because there is more direct relationship with something like physics we tend to be more impatient with the pure sciences and think about how much better engineering is and more useful, but arts is so much more removed we just don't think about it.* *Sstaff2, Jan 98*

## 5.8 Summary of cultural values and norms from Chapter 5

In this chapter, I have described practices in both pedagogy and assessment that distinguish engineering education from other disciplines. I have also analysed the cultural significance of events, reward systems and interactions with the profession and academia. Underpinning and sustaining these practices were values and norms which were shared across all of the engineering disciplines. I have provided in Appendix 14 a detailed tabulation of these values and norms, the second level of my analysis, cross referenced in each case to sections in this chapter which evidenced their manifestation as practices. I now bring together the essence of the values and norms manifested in the practices reported in this chapter.

The goals I presented in 5.2.2 were espoused values in the context of this analysis, guiding the delivery and content of the restructured degree. It is the reality of the teaching practices, and understandings around those practices, described in the rest of section 5.2, which I viewed as the manifestation of those values as cultural norms.

Several of the norms identified in Appendix 14 appear to be aligned with the changes, discussed in Chapter 2, recommended by the IEAust Review and other international calls for a change in the engineering education culture. These include:

- The explicit valuing of generic professional skills and responsibilities such as written and oral communication, and social, ethical and environmental responsibilities (5.2.2, 5.2.4, 5.3.1.4, 5.3.1.5, 5.3.2, 5.5.1) ;
- Theory taught in the context of relevant engineering applications (5.2.2, 5.2.5, 5.2.6, 5.2.7, 5.3.1.1, 5.3.1.2);
- A strong focus on Design and project based teaching and learning emphasising group and team work skills(5.2.2, 5.2.3, 5.2.6, 5.2.7, 5.6).

The inclusion of a course in Engineering Design at every year of the degree and supported by a range of other project based learning courses and their assessments, manifested their value (5.2.2, 5.2.3) as the essence of the engineering “way of thinking”. I have provided examples of the processes by which these courses built on fundamental technical or “engineering science” knowledge to provide problem-solving experience and training (5.2.7, 5.2.8, 5.3.1.1, 5.3.4) Students were required to bring together techniques of analysis, modelling and systems management to provide optimal solutions, including the making of judgements and assumptions to match the constraints within which the problem was defined.

Despite the high value placed on project based learning and design, the pragmatic realities of resource constraints both human, physical and financial (5.2.9) meant that:

- The majority of teaching was accomplished by traditional, teacher centred, lectures, laboratories and tutorials (5.2.9, 5.3.1.2)

In addition to those norms identified above, I saw teaching and assessment practices as manifesting the following cultural norms:

- The dominance of quantitative methodologies implementing high level mathematics to access knowledge, and demonstrate understanding (5.2.3, 5.2.4, 5.2.6, 5.3.1.1, 5.3.1.2, 5.3.1.3, 5.3.1.5, 5.3.2);
- A strong focus on the role of mathematics as a tool for modelling complex engineering problems (5.2.6, 5.3.1.1);
- The prevalence of reductionist or top down methodologies (5.2.6, 5.2.7, 5.3.1.2);
- Inflexible curricula with a body of “essential” technical content (5.2.2, 5.2.10);
- Problem solving was a core activity running through all courses (5.2.6, 5.2.7, 5.2.11, 5.3.1.1, 5.3.2);
- A high proportion of on-course assessment with “open ended” solutions (5.3.1.1, 5.3.1.5, 5.3.1.6, 5.3.2);
- Assessment marks were “hard earned” (5.3.1.3, 5.3.1.4);
- Engineering courses were almost exclusively taught “in-house” with inter-disciplinary links but very little contact with disciplines outside engineering (5.2.2, 5.7).

In this chapter I have particularly addressed my second research question, “How the culture is learned”. I have provided examples of the practices which manifested quite explicitly, from the first day at Orientation and throughout the first year program, the espoused values expressed in the goals discussed in 5.2.3. One of the aims of the in-house teaching of the common Part 1 papers was to introduce first year students into the engineering “way of thinking”. I have provided evidence that the first year students had developed understandings of the cultural values and norms identified above (5.2.3). These values and norms were manifested in the first year program by; the inclusion of a paper in Design with group projects (5.3.1.6, 5.3.3.2), mathematics taught from a "modelling" rather than skill-based perspective (5.2.6, 5.3.1.1), the teaching and assessment of written and oral communication (5.2.3, 5.3.1.1, 5.3.1.4, 5.3.1.5, 5.3.1.6), and a strong emphasis on theory taught using real-life applications (5.2.5, 5.3.1.1, 5.3.1.2). All of these practices and the students' understandings around them, clearly demonstrated that a process of enculturation was taking place. As part of the enculturation process, the students had also learned from the frequency and types of assessment what knowledge and skills were valued, and which behavioural norms were rewarded (5.3.1).

- Teaching practices and assessment were viewed by staff as gender neutral.

Staff exhibited no knowledge or understanding, or indeed desire to know, of the possibility of gender bias (5.2.10). No statistically significant gender differences were evident in examination results (except for two papers at first year level – Ref Appendix 12) and female students were perceived by staff as academically equivalent to their male peers. I commented earlier on the inherent danger that teaching using "real life" applications carried assumptions about norms of "real life" experiences which might advantage some students whilst disadvantaging others (5.2.5). Female students commonly identified a sense of disadvantage in assumptions of background knowledge (5.2.5, 5.3.1.2).

A prevalent attitude for staff appeared to be that "this is the way engineering is" and that students needed to adapt, whether they be females or any other student who might be perceived as having a "different" approach or background. In equity terminology, the norm was one of "assimilation" by diverse or minority groups to the values and norms of engineering education.

My examination of regular events such as Faculty meetings, provided a reinforcement of my previous (Chapter 4) identification of:

- A strong sense of a cohesive engineering identity, academically if not socially (5.5.1, 5.5.2, 5.5.4, 5.5.5, 5.7).

At the student level, the Engineering Student Society represented the traditional "face" of engineering – with high alcohol consumption and a "blokey" stereotype providing the most dominant images from student events. From student events I have identified these cultural norms:

- Students valued social activities where they identified as "engineers"(5.5.1, 5.5.5);
- Alcohol consumption was a major focus for many of the traditional Engineering Society student events (5.5.1, 5.5.5).

The latter norm was not a norm for the majority of an increasingly diverse student body, but it was shared among a large proportion of the NZ born male students and some female students and was dominant in perceptions of the engineering student culture. I also found evidence that:

- Women only events were resented by male students and staff, albeit covertly rather than overtly, in ways that events based on race or ethnicity were not. (5.5.5)

From the practices reported in this chapter I have identified several areas where tensions or contradictions existed between espoused values and appropriate manifestations in practice. The first was the mismatch between the espoused values of mission statements (Ref 4.2) and promotion criteria and the shared understandings of all levels of staff about practices relating to the relative importance of teaching and research (5.4.1, 5.4.2). As I have discussed in section 5.4 the staff perceived that the School of Engineering espoused the valuing of good teaching, as demonstrated by its Annual Teaching Awards, but were not perceived by staff to manifest this valuing in the reality of the reward systems of promotion procedures.

An area of tension appeared to exist between the common valuing of project based learning and design as “best practice” for student learning and outcomes, and the shared perception that these courses were disproportionately demanding in time and resources for both staff and students.  Project based learning also surfaced the contradiction and tension between the espoused valuing of group and team work (5.2.3, 5.3.1.6, 5.3.3, 5.3.3.2, 5.5.1), which were common practices in the engineering degree program, and the university requirement of individual assessment even of group projects (5.3, 5.3.3).

My analysis and interpretation in this chapter of the day-to-day practices of engineering education and the values and norms which they manifest, is the second of the three chapters in which I have presented findings contributing to answering my first research question. The differentiation of these practices as culturally significant rather than isolated phenomena has been evidenced in the shared knowledge and understandings of students and staff. Several sections (5.2.3, 5.3.1, 5.5.1) have been specifically included to address academic aspects of my second research question,
how the culture is learned, although processes of enculturation are included throughout the chapter. The interaction with gender has been woven throughout the chapter, but will be more directly discussed in the next chapter, in which I examine Behaviours – the responses of members of the culture to the practices and artefacts that I have examined in this and the preceding chapter.

# Chapter 6

# Behaviours

## 6.1 Purpose and outline of chapter

In this chapter, my purpose is to present my findings relating to Behaviours, the third sub-level of the observable and tangible manifestations (described earlier as Artefacts, Practices and Behaviours) of my cultural analysis. In Chapter 5 I dealt with pedagogy and assessment and other practices which were recognised quite explicitly by the participants. In this chapter I focus on the participants' tacit knowledge and understandings of appropriate behaviours in their Engineering School environment and culture. I use the voices of the participants, both students and staff, together with my own observations, as evidence of the lived experience from which I have interpreted shared values and norms (the second level of my analysis). These Behaviours appear to weave and interconnect with the Practices and Artefacts described in the previous chapters, but I have positioned them in this chapter because of their relevance as personal responses to the learning environment, both academic and social. It was my perception that these behaviours reflected to some extent the "hidden curriculum" (Margolis, 2001; Snyder, 1971) – knowledge and understandings tacitly taught and learned – rather than the explicit practices of the formal curriculum outlined in Chapter 5.

In exploring the responses of the participants, I recognised the diversity of personal values and norms brought from the "multiple worlds" (Phelan et al., 1991) inhabited by the participants, particularly their understandings of gendered identities. Throughout this chapter I have interwoven my findings regarding the formation and maintenance of gendered identities alongside understandings of appropriate behaviours, thus addressing the second part of both RQ1 and RQ2.

I begin the chapter with an examination of behaviours related to the learning environment and the forming or maintenance of relationships. Following a section dealing with language, including humour, I discuss aspects of gendered behaviour not covered elsewhere. Finally, as the second level of my cultural analysis, I bring together the values and norms that I have interpreted as manifested in the behaviours discussed in this chapter.

## 6.2 The academic learning environment

Four themes relating to behaviours in the academic learning environment occurred repeatedly in my interactions with students and staff. These were: the workload and its link with "hardness"; behaviours in classrooms and tutorials; strategies for support; and, issues around the dynamics of groups in project based learning.

### 6.2.1 Workload/Hard

One of the features of engineering education culture I discussed in the literature quoted in Chapter 2, was the international recognition of its heavy workload. In Chapter 5 I identified that a high proportion of on-course assessment was the norm for engineering education in the case study institution, as also was the prescriptive curriculum. I believe it likely that these were both contributing factors to the almost universal agreement about "hard"-ness emanating from all students interviewed. The words "hard" and "challenging" or their synonyms "tough", "difficult", "demanding" were extremely frequent, with a common acknowledgement of a very heavy workload that fluctuated in its demands from "*a nightmare*", "*horrific*", "*insane*", "*living hell*" to "*on the whole appropriate but at times …*".

When I asked students finishing their degree "what three things stand out most in your memory of the last four years", the workload and its "hardness" were always included. The term "hard" appeared to carry with it a variety of understandings and I found it useful to check its dictionary definition. The Concise Oxford English Dictionary (4$^{th}$ edition, 1951) spoke of "hard" as "*firm, unyielding, difficult (to do), difficult to explain or understand, and involving unfair or undue suffering*". Each of these meanings seems to have been exemplified in the students' perception of their workload:

> *The work is quite easy – but the workload is heavy. Lot of assignments but they are…*
>
> *Shelley, 1$^{st}$ year 1998*
>
> *I would honestly say it is the hardest course in the university. The workload was just so phenomenal. It is hard to squeeze all the material into four years.*
>
> *Samuel, 4$^{th}$ year Civil, 1997*

> *Hard work, that is probably the biggest thing. If you said engineering school I would probably say Hard yards, especially 2nd and 3rd years, it was hard to keep going and going for 9 months* *Brett, 4th year E&E, 1997*

Students, especially those doing conjoint (double) degrees compared the work they were doing, the number of on-course assignments and the hours they were working with those needed to complete other degrees:

> *Anthropology was unbelievable. One lecture a week and a fortnightly tutorial. I couldn't believe it. Compared to engineering where we had three or four hours of lectures and sometimes labs and you might have a tutorial or something.*
> *Terri, 4th year Mech 1997*

Staff verified that the change to a semester system in 1996, and the extra coursework required by an increase in project-based learning and on-course assessment, had brought about an extra workload requiring current students to put in long hours:

> *I think there has been a change in the work ethic. The current students appear to me to work a lot harder than they ever did in my time. …probably the assessment system, I think …of course we had no coursework assessment, it was purely on the final, so you could do what you liked during the term* *Sstaff1, Oct 97*

The first year set the pattern for the following years. Students, the majority of whom were straight from high school, learned quickly what to expect, as illustrated by this comment, made after six weeks of the first semester:

> *The workload is heaps more than my friends doing a BA – doesn't even compare. Really blown me away, I am used to having a break after I finish an assignment. Already I have handed in 4 assignments and have 4 to come.* *Joshua, 1st year, April 1998*

From first year, students recognised that the degree program was forcing them to learn how to work under pressure with tight time constraints:

> *Basically, I mean* ***the steel analogy*** *can be taken into quite a few levels here. The first thing is like work hardening. They put us through tighter and tighter presses every time – like cold rolling steel through the first press and then tighter and tighter, by the end of the time we are like really hard – that is what it felt like in the first semester and then they anneal us a bit with the holiday – a bit more relaxed and then a bit more again. But another thing that tends to happen is like fatigue cracking with constant repeating cycles. By the end we are totally cracked we don't feel like working any more.*
> *Stefan, 1st year 1998*

In a speech to new first year international students, a student entering the second year told them *"time management was most important thing – otherwise you would end up doing all nighters" (Diary, Feb, 1999).* In the language of engineering students, an all nighter was not a lengthy party, but a night spent without sleep to finish an assignment.

For many of the students, engineering study became all encompassing. This sometimes led to severing of relationships (at least during semester) outside of engineering, as indicated by Terri:

*…my whole life basically revolved around engineering, sport, Exec, socialwise as well as …especially during exams I would be there seven days a week, from 7.30am when my neighbour used to drop me off,* *Terri, 4th year Mech, 1996*

This pattern was perceived as continuing throughout the degree with no year or semester that offered respite. For example:

*The whole of third year was just going, going, going. You always had something on the go. At least one or two things. It was just insane. I just thought, wow, no one has it as tough as us.* *Brett, 4th year E&E, 1997*

*… fourth year there was no break – it was as soon as you finished one assignment you were on to the next. You had an assignment on this day and you'd be doing it that day purely because you had another due the day before and you were doing that the day before and you never got a chance to feel like you were catching up.*
*Karol, 4th year C&M, 1996*

A side effect of the heavy workload was an equating of learning with suffering, and shared hardship, although these were certainly not the goals of either the wider university or the School of Engineering. The shared hardship was likened to a boot camp mentality seen as binding students into a shared identity:

*It is kind of like, in army units when the unit is together, because the things they go through together. That is why there is a specific engineering culture.*
*Stefan, 1st year 1998*

*The high workload and its difficulty means that you get a kind of "shared hardship" – which ends up bonding people together.* *Brian, 1st year 1998*

Other students spoke of the workload using terms reminiscent of New Zealand's agricultural history such as "*hard yards*", and the language of rugby football ("*working through the pain*", "*being able to take it*"), identified (Phillips, 1996) as dominant in New Zealand images of masculinity.

There was a strong sense of pride in enduring and achieving, particularly from the students who were close to completing their degree or just completed. The "hardness" was valorised as a very worthwhile preparation for the future and I sensed a reflected glory – if the degree was tough and difficult then their achievement in completing it was all the more praiseworthy and worthwhile.

*Looking back, you have achieved so much. It was so tough but you managed to get through it. And you got pretty good grades and it was like the greatest achievement*
*Mei, 4th year E&E 1996*

*huge workload which perversely I found stimulating* *QuestionnaireF2 1997*

*very rewarding when you can finally do it right* *QuestionnaireF19 1997*

*if I can survive BE I can survive anything* *QuestionnaireF27 1997*

Some students used the term "engineering hardness" to mean "working hard" and for the "blokes" it also meant "partying hard":

> *It's not a particularly reliable thing but for most engineers just getting the result is an indication of "engineering hardness" even if this requires the help of others (including counsellors).* *Trish, 3rd year Civil 1997*

> *To me engineering hardness was basically how much alcohol you could consume – how hard you were as far as alcohol – as how much you could drink and how fast you could drink it* *Dave, 4th year Eng Sci 1997*

I recognised gendered images conveyed in the use of this term "hard". As I discussed in Chapter 2, much of Western thought uses duality, with "hard" associated with masculinity, and "soft" with femininity. Possible implications for female students of an environment which saw learning as "working through the pain", were well expressed in the comment made by a new graduate commenting in e-mail feedback on my initial results:

> *If engineering is a 'hard' degree, what does that imply about the women who take part in it? One of the things I've often thought I liked about E women is their personal strength. I remember reading or hearing something along the lines of women being accepted in engineering if they have that personal (masculine?) toughness. The more women are perceived to have 'soft' feminine qualities the less likely they are to be accepted. Makes sense to me*
> *Rose, Eng Sci new graduate, email feedback, August 1998*

The use of hard and soft and the linkages to gender were quite explicit in this comment from a male final year student:

> *Opposites attract and if you have got women who are thinking the same way as you and are pretty much peers, then… well I am personally more attracted to women who are softer and different …I think in this particular environment they have to be harder or appear to be more – what is perceived as masculine.* *Brett, 4th year E&E, 1997*

Throughout this chapter it will be evident that many other behaviours that I discuss were strongly connected to the understandings and assumptions students and staff have around the workload. Those cited in this section are merely illustrative of a pervasive cultural norm which had particular significance for this study because of the tacitly understood connections to masculinity.

### 6.2.2 Co-operation and/or Competition

Co-operation and competition can be viewed as antonyms, yet I found that they appeared to coexist in the learning environment in the case study institution. The individually-ranked grading system discussed in Chapter 5, together with the award of Honours, implied that these academically able students would be competing for grades and that a competitive environment was likely:

> *I'm personally of the opinion that very competitive people are actually drawn to Engineering – possibly by the mark requirements …While it's friendly rivalry, I think that rivalry certainly exists! Because everything – the grading system, the report writing format etc etc – is so new, you rely on how you're doing compared to everyone else to work out whether you're succeeding or not.* *Brian, 1st year student 1998*

> *…people are happy to give help , not assignments and say copy it, but happy to sit down and explain , as long as people have made the effort first. People want their own grades too much. There is quite a bit of competition, quite a bit.*
> *Amanda, 4th year Eng Sci 1996*

> *The competition was amongst those that wanted to be top of the class. The rest of us weren't so competitive* *Sally, 4th year C &M 1996*

From time to time, classes developed a particularly competitive culture:

> *I found that the students that were in my class they went to any great extent to achieve what they wanted to achieve at the expense of others and I found that pretty strong in our class …I found the students from Indira's class were much more friendly than the students from my class. Because of the competition, it was driving people nuts.*
> *Geetha, 4th year E&E 1996*

Geetha's perception that an unhealthy level of competition had developed in her particular class was confirmed by other students and staff:

> *Usually there was an element of collaboration where a lot of people would help each other but still end up doing their own work happily enough but there was very little of that in our class. Sometimes we were all totally daunted by an assignment but people wouldn't discuss it and openly said that they are not going to because they didn't want you to do better than they did.* *Richard, 4th year E&E 1996*

> *The class of 96 was an unhealthily competitive class, even to point of sabotage of projects. The staff were aware of this and discussed it at staff level. Felt it too late to change the class dynamics at fourth year, tried to help those who had been disadvantaged. The class of 97 had a much better atmosphere – no problem. Class seemed to be working to a common aim.* *Jstaff1, Jan 98*

Mixed in with personal competitiveness, however, the ability to seek and get help from one's peers was a strong theme throughout both male and female experiences:

> *…everyone was always like, helping everyone else get through the year*
> *Terri, 4th year Mech 1996*

> *If it wasn't for half of those guys I wouldn't have made it through year 2 as well as I did. They helped me get my head around some of those concepts*
> *Julie, 4th year Mech 1996*

> *The work was hard, stressful and impossible to achieve without a high degree of co-ordination between classmates and "working the system"*
> *Ruth new C&M graduate 1997*

I recognised the close links between the perception of a heavy and difficult workload discussed in 6.2.1 and the need for co-operation. The focus of the co-operation appeared to be on ensuring that assessment tasks were completed, especially for students of lesser ability for whom success was passing, rather than high grades.

Students spoke of the difficulties encountered if you were a “loner” by choice or circumstance:

> *Not sure if lecturers are aware how necessary it is to have helpful friends. Absolutely essential, it is not cheating but ‘how to start it’ and ‘where do you find..’ and yes sometimes ‘how to do stuff’. If you are an isolate, like when you are a split level and you don’t know anyone, well, it is almost insane* *Trish 3rd year Civil 1997*

> *You can’t be a loner in here, if you try and be a loner and finish your work all by yourself, you are not going to do it …have to offer what you know to others and they will help you back. So you really have to have friends* *Mei, 4th year E&E, 1996*

One student who exemplified the consequences of the lack of a support group was Erica, whose academic outcomes I perceived as impeded by her lack of support:

> *Because I couldn’t find a study mate to study with, I study mostly on my own … is one friend who helps me a lot but I think because he is the kind of person who is willing to help a lot, everyone goes to him for help – I don’t think I belonged to any small group*
> *Erica, 4th year E&E, 1996*

During term time, the foyer of the School usually had every table occupied by students working in small groups. In addition co-operation took place in homes, over phone lines and, increasingly in the last couple of years of my research, online:

> *Often a group of 2 or 3 of us would get together in the library or a design lab to do an assignment – it was so much easier. A, it is not boring and B, it is a lot easier working with someone else. You get through stuff quicker and you actually learn a lot from each other, when someone has a gap you help each other* *Dave, 4th year Eng Sci 1997*

Almost all of the students I interviewed, both male and female, enjoyed and valued working in a co-operative environment. They were individually competitive but saw no conflict between their personal aspirations and working with other students to gain better understanding and complete assignments. Gender research discussed in Chapter 2 aligned co-operation with femininity and competition with masculinity but this alignment was not clear cut in this study.

Male students commented, “*friends are very important*” and “*I enjoyed having mates to ask ‘How do you do this or that?’* ” but I perceived that they had less dependence, than their female peers, on belonging to a specific group. I rarely observed a female student who did not appear to have formed close linkages within a class group and I commonly observed female students working in small groups in the foyer. While these were usually co-ed groups, I reminded myself that it would have been rare in such a numerically male dominated environment to see all female groups. Staff comments supported my perception:

> *…the women tend more to work in groups, and they tend to work with other women – the women cluster together – sometimes with a male as well but almost always see women with other women… likely if you have an oddball student it is almost always*

> *male*
>
> *Jstaff1, Jan 98*

> *…especially from my NEEWS[1] experience I believe more women learn in a cooperative basis than men. Men basically more competitive even if two of them are bad they don't cooperate, the women are more likely to co-operate* *Jstaff4, Oct 97*

I was wary of generalisations around competitiveness as some female students were just as competitive and happy to work alone as their male peers:

> *… some people like S… were very competitive, she gives the guys heaps. She sets herself a goal of beating someone* *Trish, 3rd year Civil, 1997*

> *I usually study alone, yeah I don't study that well in a group – every 20 hours I do on my own there would be 1 hour with a group* *Amy, 4th year E&E, 1996*

Co-operation appeared to be a pragmatic necessity for all students in this learning environment, given the size and level of difficulty of many of the assessment tasks. Another likely factor contributing to the valuing of co-operative learning was the emphasis and prevalence of group work and team skills in design and project based learning experiences. For the majority of students, co-operation and working with others went hand in hand with the competitive nature of the grading systems. My interpretation was that they co-operated in order to be able to compete, rather than from purely altruistic motives or preferred learning styles.

### 6.2.3 Response to assessment

I discussed typical assessment practices and some responses to them in chapter 5. In this section I deal particularly with behaviours such as the "go for grades" response to assessment and its consequences for surface or deep learning, the incidence of inappropriate co-operation or cheating, and the perception of a "challenge and stretch" attitude to learning.

#### *6.2.3.1 Surface vs deep learning*

As students received information about assignments, tests and exams I saw them quickly translate this information into a series of discrete, manageable tasks, which they anticipated would be the basis for the grade they would get. They then set out to find ways of completing each task. The focus appeared to be completion of the task, as efficiently as possible, rather than demonstration of learning or understanding. As

[1] NEEWS – Network of Electrical Engineering Women Students

I discussed in Chapter 5, the goal (espoused value) of the staff teaching and assessing courses was for the students to gain understanding of theory and its consequent applications. I observed, however, a contradiction between these formal goals and what students believed they must do to attain high or even passing grades. The reality for many students was that the high volume of on-course assessment left little time for reflection, exploring content in depth, or seeking to extend their knowledge on subjects of interest. Yet their comments illustrated that they realised what they were missing and would have valued a different approach:

> *…sometimes we did not have the time to learn, just to hand in the assignments on the date they were due* *Questionnaire F8*

> *…too much in too short a time, we never had time to get into anything in depth*
> *Questionnaire M3*

Many of the behaviours I discuss here demonstrated to me that students valued the acquisition of grades, whether the target was just passing, or gaining honours. Staff, too, felt that student learning in recent years reflected an instrumentalist approach, "go for grades", "find the answer", rather than true learning or extension of knowledge.

> *They won't do it if it doesn't count for a grade* *Jstaffmember, Diary, 24 Oct 98*

> *Factor of the pedagogical climate – idea of university as a place where you find things out for yourself has gone – some of that can be based on having to pay their own fees – their attitude is "I paid my fees now just help me get out of here"*
> *Sstaff3, September 00*

#### *6.2.3.2 Inappropriate co-operation or cheating?*

The distinction between gaining help from friends and cheating was a difficult one for some students:

> *Don't understand the E-school negative team building attitude – once we couldn't do an assignment so about 5 of us worked together, didn't copy but worked until we got similar answers. Got accused of cheating even though our working was different.*
> *Questionnaire M3*

Most staff felt that incidences of cheating had increased despite efforts in the Handbook, by individual lecturers, and on the front page of assignments, to clearly spell out what constituted inappropriate co-operation, and plagiarism. Staff were appalled, not just at the lack of integrity, but at their own lack of ability to fairly assess whether individual learning had taken place:

> *I am really against cheating – it is not fair to individuals and worst of all it doesn't give a fair assessment of where they are, what holes in knowledge they might have – feel very strongly for those who don't cheat.* *Jstaff1, Jan 98*

Although I had strong indications from my own observations, conversations and evidence shown to me by staff, I asked the students for verification that copying rather than just over-helpful assistance was happening. Most readily acknowledged it did occur (although always by someone else):

> *Cheating is just too rife – I don't mind helping someone but just straight copying is not on* Karol, 4th year C&M 1996

> *Yeah, there is. Like copying assignments, they tried to make it different but follow what other people were doing – talking about assignments is OK but not the same as letting somebody copy* Amanda, 4th year Eng Sci 1996

When asked why they thought their classmates resorted to cheating, the usual answers were related to the difficulty and volume of the workload:

> *They don't want to fail and if you don't know what you are doing you probably go to any lengths to keep passing… you know – pressure on them to perform and to succeed, maybe the risk is worth it* Helen, new graduate E&E 1997

> *For a lot of people the standard was way over what could reasonably be expected of them because I would say I was about average and I was really struggling to be able to do everything.* Amy, 4th year E&E 1996

Staff spoke of changes they had made to assessment to counteract potential copying. They recognised that, by reverting to invigilated tests, rather than assignments and project based learning, they risked their assessment tasks not reflecting their goals and values for assessment, but felt they had little option:

> *We are going to change the way we assess the Software Design paper next year. It has been all assignments and projects but the amount of copying, and the very large class means we just can't tell if it is their own work – so we will have to go back to tests, which is less than ideal in a course like this.* Jstaffmember, Diary, 7 July, 00

The Associate Dean told me that very few students had been accused of cheating in invigilated tests or examinations. This was clearly "cheating" in ways that friendly assistance with assignments was not.

#### *6.2.3.3 Challenge and stretch*

Problem solving in Design is taught by challenge and expectation. Students would often drop into my room with comments like "*We have to design a windmill, I haven't got a clue where to start*". The following comments from staff and students confirmed that, whether it was design or some other open-ended project, the norm was for the task, at first sight, to seem impossible or beyond their abilities:

> *My personal view, they set you what appear to be impossible tasks initially, and as you work your way through it you discover that it is possible, it broadens your horizons.*
> *John, first year 1998*

> *In engineering you learn problem solving. You get thrown in the deep end a lot. You get an assignment you don't have a clue how to do it but engineers get taught to solve problems with what they have and what they can find out*
> *Richard, 4th year Electrical, 1996*

> *At the beginning they haven't a clue – so we give them a few ideas as a whole class – not a formal lecture but a tutorial – we talk about the science of magnetism and how to detect…* *Sstaff6, Sept 00*

One reason that the on-course assessment workload was so often seen as "hard" may have been due to the prevalence of open ended projects and assignments, which were deliberately set to challenge and stretch students to use their knowledge in ways new to them. The process of "challenge and stretch" was recognised as early as first year as "*the impossible becomes possible*". The sink-or-swim analogy was a common one as these comments illustrate:

> *You have to decide for yourself what you are going to do, use your own initiative. It is a different way of teaching. It is more like they throw you into water and you have to swim. That kind of thing. They don't provide you with floats* *Stefan, 1st year 1998*

> *You get thrown in the deep end a lot. You get an assignment you don't have a clue how to do but engineers get taught to solve problems with what they have and what they can find out* *Richard, 4th year E&E 1996*

Several staff commented on the value for the students of this process:

> *…students feel they are thrown into the deep end and left to swim – well not quite like that. The only way to learn is to gain experience but we aim to help them all the way through.* *HOD1, Jan 98*

> *The process instils the ability to "chart the unknown" – they learn a huge amount – they say afterwards the project just blew us away but we survived and learned really valuable life skills* *Sstaff6, Sept 00*

Another staff member thought the course did not have enough

> *…relatively minor experiences which are really individual tests of guts, intestinal fortitude or whatever.* *Sstaff1, Oct 97*

I found it difficult to discern whether this style of learning, "throwing in the deep end", "charting the unknown" was familiar for both male and female students, but my background as a teacher led me to believe it was not a feature of the high school education that most students had experienced. For many of the female students I encountered, being pushed to their personal limits physically or academically, was not part of their socialisation, and some had led relatively sheltered lives. Although retrospectively they were proud of their achievements, I noticed it appeared to have been an uncomfortable experience for students who had always considered themselves high achievers.

> *At school I was an A student, and now I am just so glad when I pass and getting a B is a real triumph* 2nd *year E&E student, Diary, 1998*

### 6.2.4 Stress and coping strategies

Both male and female students spoke about stress, in relation to the workload, in the interviews and in informal conversations:

> *I think some people go round talking about how stressed they are and they talk so much about it they get that way* *Joshua, Diary 25 Mar 99*

> *Oh, my stress levels are really up!* *Rebecca, Diary 25 Mar 99*

> *Some people didn't cope very well at all. Just ended up having problems sleeping, staring at things for hours and not getting anywhere at all, and that just makes you more stressed.* *Dave, 4th year Eng Sci 1997*

Students' response to stress appeared to have links to gendered socialisations. "Keeps his emotions to himself" was a feature of New Zealand masculinity (Phillips, 1996), which I often saw played out in this setting. Regardless of the provocation, female students and staff agreed that the only places to get emotional in the engineering school, particularly to cry, were out of public view in places such as the washroom. They all felt crying carried implicit understandings of weakness and inadequacy, which were linked with femininity:

> *…like a couple of times I broke down in front of a male lecturer, really embarrassed me, something I really hate doing, like I just think "female reaction I shouldn't do this", but I couldn't help it, I was just so stressed out at the time.*
> *Kerry, new graduate Civil 1996*

> *She burst out crying in front of me one time …I didn't know what to do with her… I have never had a young person, a man cry in front of me.* *HOD2, Jan 98*

> *…I try not to, and avoid situations when I might… I think it is a natural response, we cry when we are angry or frustrated and I don't think the men understand… I hate to…*
> *Jstaff2, Oct 97*

I spoke earlier of the recurrent theme that supportive friends were a necessity for academic survival. Those students who were high achieving appeared to have found strategies to deal with the heavy workload and consequential stress. One young man commented that:

> *…when it all gets too much, I go across the road to the Rec Centre and lift a few weights, then I can come back and start again.* *Brian, Diary, 14 May 99*

and another:

> *I make a list and prioritise it and get it done.* *Joshua, Diary, 25 Mar 99*

Several of the final year students commented that they had found the stress levels so high that at various times they had wanted to leave. This usually seemed to occur at third year when all courses were compulsory and the end was more than a year away:

> *In third year I felt really, really stressed. I desperately wanted to give it up. I knew I couldn't give it up and knew I didn't really want to give it up but sometimes I used to think, "If I only could get out of this".* *Melanie, new graduate E&E 1997*

Time management was a coping strategy that was not officially taught, but identified by several students as one of the most important things they had learned:

> *…one thing I learned was to manage the little time you had at varsity and using resources, doing research and acquiring all that. That helped the workload – the time management. Okay, this one is due this day and this is due the next day and if two were due, you would work out which had the higher weighting on the marking and apportion your time that way* *Samuel, new graduate Civil 1997*

Learning time management was undoubtedly a skill that was likely to be required in their professional lives. It was an offshoot of the high proportion of on-course assessment, the challenging and stretching nature of this assessment and the strong commitment students had to passing the course.

Female students had the opportunity of coming to me in my role of Liaison Officer for Women in Science and Engineering for support, and, even though the majority of the female students did not use this support, they appeared to value my presence.

> *I felt that it was important knowing that you were there even if I didn't need you…*
> *Heather, 4th year E&E 1996*

Male students and staff spoke enviously of the extra pastoral care available to female students and regretted that such systems were not in place within the School for all students.

### 6.2.5 Classroom/tutorial behaviour

In Chapter 2, I discussed the important role classroom dynamics and interactions might have in a cultural study (Mclean et al, 1997; Tonso, 1997) in providing insights into the processes by which students learn and maintain cultural values and norms. I recognised the influence on classroom behaviours of the artefacts and practices described in Chapters 4 and 5, such as the diversity of the student body, traditional teaching practices and the physical environment. One example of this influence was at first year level. Being in the same lecture theatre for all lectures, with the same group (albeit a large class of over 200), and few vacant seats available, quickly facilitated a close interaction between students:

> *It's really cool. Anybody can come in and sit next to us, and you talk to the person next to you even if you don't know them* — *Barbara, 1st year 1998*

The friendly camaraderie experienced, albeit often task-oriented, was of high importance to the students, and not necessarily observed in lectures on other parts of campus:

> *The way engineering is set up it is easy to make friends. I was talking to my commerce friends and they don't make friends, don't all take the same papers*
> *Alex, 1st year 1998*

#### *6.2.5.1 Disruptive behaviour*

Several Australian researchers have described engineering classrooms as displaying boorish and disruptive behaviours (Jolly, 1996; McLean et al., 1997) and my own observations, twenty years previously, as a student in first year courses common with engineering students, had been somewhat similar. In this study I observed that, despite closely packed large classrooms, disruptive behaviour was not a regular feature and was no longer tolerated by staff (with some exceptions) or in some instances by other students:

> *You used to find paper fights and darts… I mean I never had any problems because I won't stand for it, but I know other people did. It has improved a lot. Some well known staff members whose room was in a complete shambles afterwards*
> *Sstaff2, Jan 98*

Occasionally unacceptable behaviour still occurred. When I sat in on large first and second year classes in May 1997, I noticed the students were very quick to express disapproval of poor lecturing style in the form of poor diction, language skills, boring delivery and poorly prepared illegible overhead slides. Their disapproval was expressed by an ever increasing undercurrent of chatter, movement and occasionally a loud comment from the anonymity of the back rows. I saw these behaviours as arising, in part, from the anonymity afforded by a very large group:

> *…large classes are so bloody impersonal and in large classes our students don't have good social skills, they don't know how to shut up* — *HOD1, Jan 98*

and lecturers who did not see class control as part of their role:

> *I'm here to provide information, if they don't want to listen, so be it*
> *Diary, May 97*

The major noise and disturbances appeared to come predominantly from the back rows, from groups easily identifiable as male European, but chatter and inconsiderate behaviour, were prevalent across all ethnicities and both sexes.

Paper darts were less frequent at the time of this study than I had observed in my own student days, but as the following student comment illustrates, they were still a feature of engineering classrooms:

> *We are engineering students, we make the best darts, usually only at the beginning and the end though* — *Rebecca, 1st year 1998*

First year students attributed the noise and chatter in their classrooms to the easy familiarity that quickly developed:

> *The first week, the lecturer came in and said "You are quiet" and that only lasted a couple of weeks and now people talk to people on the other side of the theatre without getting up* — *Jaya, 1st year 1998*

> *And you walk into the engineering lecture theatre and the poor old lecturers have a problem getting our attention because we are all talking* — *Shelley, 1st year 1998*

Students appeared to be more focussed at higher levels, although their behaviour continued to reflect an intolerance of what they judged to be "poor teaching".

> *We were mostly very well behaved I think, unless the lecturer was really incompetent, like mumbling to the board, and then we would give them a really hard time*
> *Brett 4th year E&E 1997*

I did not observe disruptive behaviour in the large classes at higher levels other than a progressively more restless atmosphere, in response to a visiting lecturer who had not kept the attention of the audience. Visiting lecturers spoke of these large engineering classes as a demanding group, and those who had lectured to them previously were conscious of the need for good preparation. One new staff member had heard from other staff on campus that engineering students had a reputation for bad behaviour and was pleasantly surprised:

> *I was quite worried about it, teaching engineers, they had a reputation and mostly men, and being a small young woman I was a bit intimidated. When I started teaching them I was amazed at how docile they were, they really just wanted to get those notes down*
> *Jstaff2, Oct 97*

There was agreement from most staff I spoke to that "*the classroom environment nowadays was much more pleasant*" (Sstaff5, Oct 97). Some directly attributed this to the positive influence of women on class response and general behaviour, *"I think it has been completely due to the women, women just don't do that sort of thing*" (Sstaff2, Jan 98) but other staff suggested that "*the involvement of more women has been overshadowed by the number of students from other ethnic backgrounds"* (Jstaff2, Oct 97), *"yobbo style is slowly fading"* (Sstaff4, Jan 98), "*it might also have something to do with getting the material in and getting out of the place to pay back the student loan"* (Sstaff3, Sept 00).

I observed also that students attended well when there was notetaking to be done. As soon as a lecturer diverted from the topic or said “don’t write this down…” a level of paper shuffling, or murmuring started. I inferred that overt disruptive behaviour may have declined but that students tended to be quite instrumentalist in deciding which parts of the lecture needed their attention.

Although female students were as likely to be involved in the chatter as their male peers, their behaviour style appeared to be less confrontational or disruptive even when classes got restless. This gendered difference in behavioural style was reflected by more than one comment from staff members who saw the increased participation of women as “civilising” which appeared to imply that the previous culture was accepting of an “uncivilised” (male dominated) environment.

The language used by the students appeared to me to reflect these gender related styles of behaviour. It was a male student who spoke of “*giving the lecturer a hard ti*me” whereas female students commented, “*we went to sleep, or chatted about an assignment*”. I occasionally witnessed arrogant and intolerant behaviour in groups of NZ European male students and in more recent years male students of other ethnicities. These groups were not dominant numerically, but in a classroom situation they had the power to dramatically influence the learning environment for other students.

#### *6.2.5.2 Seating arrangements*

My observations of lectures revealed very constant, self-chosen, seating arrangements amongst students. Patterns were evident within weeks in the large first year classes, despite such cramped conditions that latecomers had very few options. When I asked first year students about the seating arrangements in the lecture theatre they gave almost identical responses, and several drew diagrams – it was clear they had a very good visual image that relied on judgements of race and gender:

*They do sit in the same places*
*Mixture female and male, mixture race –*
*Malaysians sit here – the ones who speak English*
*Indian group most of them girls normally sit here or here on the side*
*Group of middle eastern people which not quite sure – also mixed gender*
*The European Kiwis sit here and here – there is a Chinese bunch which is always sitting here….*
*Another group which is Malaysian Chinese girls and they normally sit here or here*
*Asians normally here in the front and some Europeans*
*The hostel people –*
*The European Kiwis – the ones who say Yeah mate… Most Europeans sit at the back*
*Alex, 1st year1998*

*Asian people sit in the centre block and the intelligent students sit in the front*
*Also the Arabic type ones sit towards the back of the centre*
*And the Indian etc over on the left ….on the front left and right*
*Some Grammar boys behind them, and the St Kents boys sit to the right middle of the back section* *Shelley, 1st year 1998*

These students clearly recognised gendered as well racial identities in their fellow students! The male student quoted here classified his fellow students both by his perception of their race, and noted where the girls sat. The female student was very aware of the location of the male students even down to which schools she knew they came from.

It appeared to me that female students were comfortable sitting anywhere in the lecture theatre although they were often in small groups and sometimes seats were saved for them. They were definitely not all in one locality but spread out round the lecture theatre. Although large blocks of students appeared to be clustered according to race, my own observation confirmed this student's comment:

*…they are not just groups of twos and threes but big blocks and interfaces between all of them that overlap. So when you talk about the boys at the back there is a line of them but there are about four or five rows and they sort of swap round, the groups are really big.* *Angus, 1st year, 1998*

I observed a continuation of these regular seating patterns in the upper level classes:

*Feature of the electrical class, in 2nd year there were 120 and 84 of them were of Asian descent and they would plonk themselves in the middle block of the classrooms and all the Europeans would be on the outside and that physically drove a wedge right through everyone from the start from that standpoint* *Richard, 4th year E&E, 1997*

#### *6.2.5.3 Behavioural differences in large and small classes*

I have discussed the effect of class size on teaching practices and the prevalence of lecturer centred transmission of knowledge in the larger engineering science courses in section 5.2.9. Behavioural responses to these practices drew my attention to two major issues, particularly for those students who were minority group students. The first of these was visibility, and the second, linked to it, was the potential for interactive teaching and asking of questions during class time.

At first year level, all classes except tutorials were over 200 in size, and the anonymity of being one of such a big group had negative aspects, such as the potential for inattention and disruption (as I have commented earlier in 6.2.5.1), as well as a feeling of being "*one of those nameless faces that filled the lecture theatre to overflowing on most days*" (Brian, 1st year 1998). My observations confirmed that although they were "nameless faces", this anonymity, and the cultural diversity discussed in section 4.7.1 could be viewed as an advantage for students who might otherwise feel part of a minority group, either ethnically, by gender, or because of a disability. They were able to mix in and belong without feelings of high visibility. I noted that relatively few students asked questions in this large first year class. Lecturers wanting interaction were, however, able to get response to questions put to the class, provided they chose volunteers to answer questions, or a show of hands approach rather than singling out individuals. Few female students asked or answered questions in this public arena, and in this regard, the potential for attracting attention was illustrated by the following well remembered incident:

> *I can remember the first time I asked a question in first year, right at the start and we were in a huge lecture theatre and I asked a question and as soon as the guys heard a female voice all these heads swivelled round to see where the voice was coming from. I remember that.* *Chloe, 4th year Mech 1996*

The unwillingness of female students to ask questions in class carried on past first year to later classes:

> *I didn't ask questions in class, even though I was an extrovert when I was out socially, I always had to make sure it was very intelligent, that I really knew all the basics of it and I was pushing the class a little bit further.* *Sophie, new graduate Civil 1997*

> *In lectures I can almost guarantee that no woman will ask a question. It is a double whammy, one is they are a minority and they don't want to be even noticed sometimes… I have seen that in my experience almost all the women keep their mouths shut. The guys ask questions be it smart or dumb it doesn't matter.* *JStaff4, Oct 97*

Differences in potential staff-student interactions, and behaviours in classes, accentuated as students moved into their specialisations, were illustrated by the following comments:

> *What probably stands out was how impersonal a lecture was as opposed to a classroom at school… That is probably the main thing. You are in there with 80 guys, none of*

*whom you know, a lecturer you don't know who doesn't know you or even intend to know you, so you are basically transcribing what they are saying.*
*Brett, 4th year Electrical, 1997*

*The atmosphere in E. Sci was also great – Classes were small so there was a lot of interaction between staff and students* *Rose, new graduate Eng Sci 1997*

Some class groups remained over 80 in number, and others such as Engineering Science and Chemical and Materials Engineering were always under 40 and even smaller in advanced elective subjects.

All students enjoyed the closer interactions that the smaller class sizes in tutorials, several departments and in electives at fourth year level made possible:

*He had a lot of discussions and he would say "I'll give you a problem" and he'd think of one off the top of his head and everyone would just put in a little bit, but if you're in a big class you can't really do that sort of thing.* *Amy, 4th year E&E 1996*

*In out tutorials, like Design, everyone knows each other in the class and you can greet each other and talk about stuff.* *Michelle, 1st year 1998*

Although the participation of women had gone up to 20% during the time of this research, I was very aware that there were classes and tutorials which might have only one or two women, which made them very visible amongst their male peers. This visibility was experienced by female students in a number of ways, not always problematic, but recognised by them as meaning that they were not anonymous students and their absence or behaviour was likely to be noticed:

*Being one of only 3 European women I guess we were all very easily recognised and I'll often have people recognise me who don't even look vaguely familiar to me.*
*Helen, new graduate E&E 1997*

The high visibility came as a shock sometimes to female students who thought they were anonymous faces in the crowd:

*I always thought the lecturer would come and see this big blur …and one day I was just coming out of the lifts and there was Dr R. standing there and he said "hello Miriam" and I was so shocked that he knew my name that I just went back to the lift and came downstairs and cooled down for a moment. Because I remembered all those times I was just drawing on the paper and chatting and laughing and not paying attention to what the poor man was saying.* *Miriam, 4th year E&E 1996*

My observations in small group tutorials at first year level revealed that the students mixed comfortably together. The female students predominantly sat either with other female students or with male students from their own ethnic backgrounds.

From time to time, female students spoke to me (in my working role not my research role) of incidents which they tried to dismiss as minor but annoying. My perception was that, if they were annoyed enough to come and speak about it, then the incident had disturbed them. It seemed likely to me that these occasions were illustrative of the frequent reminders in classrooms and tutorials that they were not just engineering students, they were women:

> *We don't need reminding we are a minority, we can hardly fail to be aware of it but he makes us feel very visible in a way we would prefer not to have. Like when handing back a paper or anything somehow it comes out as "here is yours young lady" whereas with the guys it is just "here is yours" and every second question is to one of us.*
> *Annie, 1st year student Diary 6 August 97*

### 6.2.6 Behaviours in Group Projects

Group projects in Design courses as well as other discipline specific courses were a feature of the U of A degree. I have discussed the practices around the teaching and assessment of these projects and their related values and norms in Chapter 5. By the end of the first year, students had learned that teamwork skills and applying theoretical knowledge were valued:

> *The other thing was teamwork. You do have to think about that, they have been drumming it into you.* *Angus, 1st year 1998*

> *The teamwork thing is also really important. More important than I ever thought it would be.* *Rachel, 1st year 1998*

Although staff appeared to perceive the projects as teaching the students to work in teams, my observation was that group and teamwork skills were not so much "taught" as "learned". Students were given a brief introduction to the theoretical knowledge of team building techniques, but it was the repeated exposure to group projects, requiring team work for successful resolution, that I suggest resulted in the learning of these skills. This exposure to group projects started at first year, and the experience of a large number of students, was exemplified in the following comment:

> *They did talk to us about teamwork, but as it proved with the project, theory is not the same as practice* *Stefan, 1st year 1998*

In this section I report on the behaviours of students in situations when they were compelled to work in groups on projects, including those with both self chosen and assigned partners.

My observations in Design tutorials during the first semester and at the testing of the first project suggested that many of the female students were in the thick of the "hands-on" building of the truss, the first design-and-build task. My interviews with first year students occurred later in the year at the conclusion of the second design-and-build group project. I noted with some surprise the almost unanimous response from the students, both male and female, that demonstrated stereotypically gendered behaviours.

> *A lot of us girls have talked about it and said in our group, the boys did all the building and drawing and the girls got stuck with the secretarial stuff.* *Jaya, 1st year 1998*

> *We joined in but the guys were the ones who had the big shot ideas "We should do this and this" and the girls were more reserved and sort of "You do that and we will do our share doing the calculations… The guys were in charge more likely but they were the ones more spurred on with the building…* *Sue, 1st year 1998*

> *In the end I did the entire design. I did it at home and at Uni, the technician helped with the wood and wire. The Hong Kong girl and the Malaysian girl did the report*
> *Simon, 1st year 1998*

When these first year students were in mixed sex groups, the norm appeared to be for the male students to be "*the ones spurred on with the building*", "*having the big shot ideas*" "*the innovators*", and the female students were "*organiser*", "*mediator*", "*wrote the report*" or "*did the calculations*". These comments were confirmed when I watched the testing of the projects. I observed body language which clearly demonstrated that, in a mixed group, the male members were very proprietorial about the mechanism. Although all the students in a group laughed and spoke about "our" mechanism, the norm was for it to appear that "ownership" resided with the males. My disquiet at the time of those observations was that, for the majority of young women who conveyed an impression of non-involvement in the preparation and design of the mechanism, the potential existed for a detrimental effect on assessment of their contribution by their tutors or peers.

The following comments demonstrated that those female students who were confident enough, both personally and with regard to the project, to speak out, did not willingly acquiesce to being left out of the "practical stuff":

> *I told them, actually to get less drag you have to have it on the outside and they just wouldn't damn well listen.* *Shelley, 1st year 1998*

> *I am doing my design project with a guy from the hostel who is helpful but seems to think that "girls can't make things" and I have to keep saying "give me a go"*
> *Jill, Diary 14 Sept 98*

From anecdotal evidence, reinforced by my interviews, a number of the students, both female and male, were entering with a strong academic background but little exposure to practical skills. I observed large numbers of students of both sexes who, although enthusiastic, were not confident with tools, and did not appear to have a "tinkering" background of any sort. Some of these found it difficult to transform theory into a workable design:

> *I haven't done a lot in doing or making. I talk a lot. This group didn't have good ideas. The Kiwi make sample before discussing, but not very good. Woman didn't have ideas. The Taiwanese had an idea, but no idea how to do it – just like "use a propeller"*
> *Jaimie, 1st year 1998*

Although this lack of a "tinkering" background was not gender specific, my data suggested it was common for a high proportion of the female students, which I inferred may have contributed to the above mentioned stereotypical allocation of roles within a group.

The majority of the male "Kiwi" students I interviewed had described hobbies building boats, models, and the like. One student who had experience in holiday work commented:

> *I did many things that I think help me get a grasp of some of the ideas in engineering, like beams and trusses in houses. Having seen and built them, you get to understand how they work faster* *Joshua, 1st year 1998*

I thought it unsurprising that he followed on with the comment:

> *I didn't think there would be so many theory based people who have very little practical knowledge of anything.* *Joshua, 1st year 1998*

Time management was another issue for students involved in group projects, especially at first year. I spoke earlier in this chapter of the student perception that the workload was teaching them to work under pressure within time constraints. For the first year students group work was made more difficult at this early stage of their degree by a perception of gendered trends in time management. A number of female students spoke of the "last minute" tendencies of their male colleagues and the clash with their own preference to be well prepared:

> *My last group were boys – I had to drag them away from their card games. They used to say "girls always worry…" I had to be the motivating force, guys are so lazy, they wait until the last week or so* *Sita, 1st year 1998*

> *I was trying to get together with them so we wouldn't have to rush it, but they delayed it, then they panicked two days before the end.* *Teresa, 1st year 1998*

I was wary of interpreting that this was a gender specific trait in this context, but it did appear to be gender related. Senior female students spoke about themselves, and were spoken of by partners, as the organisers, the ones who:

> *…made sure we had meetings and watched out for the time line*
> *Terri, 4th year Mech 1996*

> *When I worked in a girls group we had a habit of working a bit more gradually. Like when I worked with guys we basically did the whole thing in the last weekend*
> *Miriam, 4th year E&E 1996*

> *We had this girl in our design group who had real leadership material. She took it on herself to be the manager of the group and organised us, told us what we had to do, set deadlines, gathered it all together. It was the best group I have ever been in.*
> *Scholarship Interview Diary 9 Aug 97*

The first year students often struggled with the effort to build a team from groups of diverse individuals but comments such as Brian's illustrated that they recognised that even with difficult groups a learning process was taking place:

> *I actually had a personality clash with one of them. He just decided he didn't like me and that was that. That kind of thing is quite interesting because you have to learn ways of getting on with the person, getting the project done while still while getting round that issue.* *Brian, 1st year 1998*

Approximately half the students had English as a second language, and this was spoken of by students as sometimes causing difficulties:

> *I did my truss project with a couple of people with thick accents and they were less inclined to speak up in a group – they could understand English good enough to understand what you were saying the whole time but not the confidence to speak up*
> *Rebecca, 1st year 1998*

> *There was an Asian fellow in our group. I think he found it difficult to keep up during brainstorming sessions (and "heated debates") and also had an obvious lack of practical experience. Overall, however, the group was able to function well, as his English was more than adequate* *Laurie, 1st year 1998*

Although confidence in speaking English was essential, the students discovered that communication was the most important factor for a group to function effectively and differences in communication styles were more than just lack of a common language.

> *Yeah, it wasn't just language it was the way people thought about it and the way they did it... It was trying to put it the right way and understand what they meant*
> *Michelle 1st year 1998*

> *Not a good experience – crappy partners – they never give any ideas, or argue with my ideas or say No. I give ideas and they say OK – and what now…* *Teresa 1st year 1998*

The lecture on team skills in first year Design had used terms for the roles of different people in a design team such as "shaper" and "finisher", but no strategies for resolving and working with personality clashes or language difficulties. From the comments above, group dynamics appeared to be more of a problem than the technical one of finding a design solution. It was left to individuals to mediate when major difficulties arose and, from the comment below, I wondered whether the role of "mediator" should have been added to the team roles:

> *I found that when they were having problems communicating they would come to me and I was going and talking to them separately… Otherwise the Asian guy would have*

*been left out completely. Because when they were sitting they would like, close their backs off to him.* *Barbara, 1st year 1998*

As students progressed through their degree, lessons learned from earlier situations were applied. They had begun to match their preferred way of working with other like-minded students, as illustrated by these comments:

*You chose people you could work with and were about your equal and you came out with a project where you all contributed and achieved rather than the groups where one person does all the work and there were tag alongs and in some groups where a couple of people know how to work and a couple who want to but don't know.*
*Dave 4th year Eng Sci 1997*

*Right after the Year 3 Design competition finished a lot of people started pairing up then, and that is when I realised who wanted to work with who.*
*Geetha 4th year E&E 1996*

There were still occasional dysfunctional groups, especially where partners had been allocated. The final year projects, as described in the practices section 5.3.4, were viewed by staff and students as probably their most significant course. When partnerships became dysfunctional, what was described as a "wonderful achievement" by most students had the potential to turn into a most distressing experience. Dysfunctional partnerships were not gender specific, as these examples show. I saw them as more liable to occur when expectations and background experience diverged and communication was poor.

*I was quite relieved when it was over… I am just so glad that I don't have to go through this again. I mean it was just to the point when I didn't want to talk to her or ever to see her again, very sad and stressing memories that she represents. But after a while you get to look at it more of a bigger picture and it is sad and all that and I have learned a lot and if I hadn't done that project I probably wouldn't have learned as much.*
*Miriam, 4th year E&E 1996*

*Near the end I was getting on my partners nerves and he was getting on my nerves and I think we were both glad when it was over… I knew he was a hard worker and had good grades… but it turned out that he was too hard of a worker. He was basically getting annoyed with me because he seemed to be doing more work than me so it was a bit uneven.* *Chloe, 4th year Mech 1996*

Increasingly, as students moved through the degree and group projects were compulsory rather than a matter of choice, students were forced to take a variety of roles and the stereotypes noticed at year one became blurred. All-female partnerships were not uncommon, which forced students to tackle tasks they might otherwise have backed away from:

*…we talked about who is better at what and who would do what… ours was hardware and software – actually both of us did the hardware, the hardware bit was basically assembling the camera and hooking it up to the computer, it wasn't much hardware. The bulk of it was software.* *Mei, 4th year E&E 1996*

*…we both had something to do with every part of it. A lot of the projects they split with someone doing software and someone doing hardware but because ours was all software we had to work together so we had to both be doing everything*

*Heather 4th year E&E 1996*

Lectures on Project Management in the third year provided more tools that students could add to their team management skills repertoire and I observed that a level of professionalism had developed in the approach students were taking, as exemplified in this comment:

*…we did one of those nice little Gant charts and assigned a leader to each different aspect of the project so we divided it into about 12 and everyone had about three things to do and that person was responsible for it but didn't have to do it all themselves. That way everyone had something they were in charge of but there was not any overall difference* *Karol, 4th year C&M 1996*

As I indicated earlier, some of the group dynamics made it difficult for students to realise, to the full, the opportunities for learning offered by group projects. In particular, when the dynamics of the team were stressful it appeared that full understanding of the technical knowledge and its application became sublimated in the need to achieve some sort of result.

As I watched students progress through the degree over the period of this research, I observed an increasing maturity and confidence in their participation on this type of coursework.

*- by doing this project I learn how to learn and I finally find out actually engineering life is not as bad as what I thought before.* *Stella, $4^{th}$ year E&E, 1996*

*Ive learned a lot of skills like personal skills and how to work with people , how to deal with people, how to work in a team how to deal with difficult people*

*Karol, $4^{th}$ year C&M, 1996*

It seemed evident to me that the focus within the case study institution on Design and project-based learning was providing frequent and varied opportunities to develop the skills in group and team work that were valued in the goals of the degree outlined in Chapter 4.

## 6.3 Relationships

As I have discussed in Chapter 3, Schein's theoretical framework for cultural analysis (Schein, 1985, 1992) proposed that the beliefs and assumptions around relationships between people formed one of the dimensions that defined a culture. Thus, I saw an understanding of the way people interacted with one another both academically and socially as an essential component of this study. The types of relationships I have referred to in the following sections are the regular patterns of interaction not officially defined by an organisational role, other than the distinction between staff and students.

### 6.3.1 Staff

The nature of staff relationships appeared to be causally linked to the behaviours and practices that I have already discussed in the sections on buildings and facilities (4.4), the staff profile (4.7) and events (5.5) although which was cause and which effect I found difficult to determine. Aspects of staff relationships that were highlighted in these sections included a high degree of interdepartmental interaction, non hierarchical and informal communication styles, and the rapid diversification in recent years of the staff profile. In reporting my results I have chosen not to delve deeply into all aspects of staff relationships. Staff relationships are linked in a complex web involving research groups, promotion structures, age and ethnic diversity, which I felt was beyond the scope of my study. Although I acknowledged relationships were an integral part of the culture of a particular institution, the focus of my study was on the culture of the discipline exemplified in this case study, rather than an analysis of the organisational culture of the institution.

A major inhibiting factor in my reluctance to analyse staff relationships in depth was the likelihood of invading the privacy of the very limited number of female staff at the time of the study (averaging 7 out of 100 academic staff). I saw it as significant for this study, however, that the women staff were a diverse group, without the traditional enculturation in the local culture of many of their male colleagues. All had been educated at overseas universities. Only one department had more than one female staff member. The female staff did not “cluster” together and they participated only irregularly in academic women’s groups on campus. They enjoyed each other’s company and took the opportunity each vacation period to have an informal gathering over lunch at an off campus location, but teaching and research, combined with family commitments, left little time for further social interaction.

### 6.3.2 Staff – student

I recognised the important cultural role of staff in an educational institution with students passing through at four or five yearly intervals. Staff were the holders and transmitters of the cultural values and norms of engineering education and their beliefs and assumptions around engineering education, manifested as behaviours and practices in relation to the students, were vitally important to the students' enculturation.

The awareness of power and lack of power, I saw as an ever-present component of staff-student relationships which tempered all interactions. Students came to realise that the anonymity of early, large classes was gradually lost in the discipline specific classes but their awareness of the power differential was revealed in such ways as: gauging the appropriate level of respect or familiarity, and how much "ignorance" to reveal in asking questions. The easy familiarity with authority figures, which I believed to be part of the Kiwi style, was reflected in the way many students and staff were comfortable with the use of first names rather than titles. In my interviews with final year students, and even first year students, they spoke of staff as "Andrew Smith", or "Dave Rowan". When introducing themselves to students at the beginning of a lecture series, many of the staff would leave off any title. As a consequence, new graduates told me they were not aware which of their lecturers did not have PhDs or which ones were Associate Professors. On closer analysis of my interview data and further reflection, I realised that the easy familiarity that I had identified as applying to the majority was in fact dependent on personal culture and experience. This was confirmed by the following comment:

> *I think academic staff have less contact with the Asian student population than with Pakeha students* *staff member at feedback seminar October 1998*

More formality and respect in relationships with staff were evident in discussions and interviews with students from an Asian or Polynesian background who were relatively new to New Zealand. I noted that they always used either a title such as Professor Smith or Dr Brown, or the surname without any title or first name.

First year students were sometimes apprehensive about approaching lecturers and, by the end of their first year, were "*still a bit nervous – he is the lecturer but like to talk to him…*" (Jaimie, 1st year student 1998). Once into their departments and class groups, relationships between staff and students had the chance to develop, as the following comments illustrated:

> *At first it was quite intimidating meeting lecturers and having to go and be ignorant and say "How do you do this"…by fourth year a completely different story. You feel you are treated as an equal – no barrier which you could consider there*
> *Richard, 4th year E&E 1996*

> *The majority of the lecturers were very friendly and helpful and I enjoy the first name informality that has developed with some of them* *Questionnaire M10, 1997*

> *…with Dr G… he is like Mum looking after the students it was quite nice*
> *Erica, 4th year E&E 1996*

> *…with engineering science you get to know the lecturers really well and they get to know you – small class helps* *Dave, 4th year Eng Sci 1997*

The relationship between staff and students as I observed it, was of the academic mentor/mentee type rather than true friendships. Students were clearly still aware of the power and sometimes generational differences. The majority of students believed that staff were approachable and willing to help, although several students spoke about an unwillingness to expose themselves to ridicule:

> *I would sooner sit down and bash away for four hours and the lecturer could fix it in five minutes …but pride I think, I don't want to go in there and get humiliated …maybe I am a stubborn male…* *Richard, 4th year E&E, 1996*

The majority of female students perceived that they were given help more readily than their male peers:

> *I had the feeling throughout the engineering school not just in Engineering Science that women generally would get more help than a man – maybe some of the lecturers thought the women couldn't do as well… whereas the guys would get turned away with Go and work it out yourself …it was never a feeling of go away you're female, it was more Come in you're female.* *Peggy, new graduate Eng Sci 1997*

> *I think lecturers are probably softer on female students, like if you have problems, if I was a male student and went to them for help, they wouldn't help that much, so as a female you are probably better…* *Mei, $4^{th}$ year E&E 1996*

There were two aspects of this perception that concerned me. Firstly, I saw this behaviour as implying that staff believed women needed extra help (i.e. were weaker or less knowledgeable) whereas male students should be encouraged to be more independent. This seemed to reinforce stereotypical gendered socialisation rather than encouraging independent learning habits from all students. Secondly, I was concerned that, for female students, their gendered identity (with all its social and sexual connotations) in an environment of predominantly male staff was providing them with different treatment to their male peers, regardless of whether this was occurring consciously or subconsciously.

I was reminded in interviews and my observations of daily interactions that, despite their efforts to avoid stereotyping, staff were very aware of the gendered identities of their students and carried preconceptions and expectations, particularly for female students. It appeared to me that some staff found relationships with female students less predictable, and requiring more care, than those with the male students they had been used to. Staff spoke of difficulties their colleagues encountered in interactions with female students:

> *…even today there are some staff members who are still having trouble adjusting to how you deal with women… some are genuinely trying but beaten by it – human nature*
> *SStaff 5, Oct 1997*

> *Staff now are more aware of gender issues – watch their ps and qs. Some still think women are 2nd class citizens. There is an awareness of potential harassment – GB won't have a female in the room without the door open.* *HOD1, Jan 1998*

Some female students spoke perceptively of the difficulties staff might encounter:

> *…staff are people (older men mostly) who have never been anywhere else other than school, university and maybe engineering work – and women haven't been involved in their working lives (except in the office) – how can we expect them to treat women in the classes with the same respect as the men in the class?* *Trish, 3rd year Civil 1997*

> *The lecturers seemed to have a bit of difficulty relating to us – they occasionally seemed resentful or sometimes even scared that we were going to bite them.*
> *Ruth, new graduate C&M 1997*

I realised that while it was human nature to have expectations and preconceptions based on personal experience, stereotyping had particular consequences for female students in this setting, where to be female was still to be "different". Academic staff and technicians had power, not only in terms of assessment, but in terms of the unspoken messages they sent students – messages which impacted on confidence, a sense of belonging and the reinforcing of certain behaviours. Comments such as the following were indicative of the range of understandings around gender held by staff:

> *You can be more critical/direct with male students "you should know this". With women students you can't be as direct, they can get upset. I try to be more diplomatic – tend to start them en route to solving the problem… I think that if I treated women the same as men I wouldn't see that woman again* *JStaff1, Jan 98*

> *I think they have a different way of seeing things, whether it is cultural or genetic really doesn't bother me, it is different and consequently the profession stands to gain from it*
> *SStaff5, Oct 97*

> *Lack of confidence – definitely. I don't know if it is because the males do not express it, even though they might be feeling it but women are much more free at expressing it*
> *JStaff4, Oct97*

*Women are much better at planning, they tend to think ahead. Boys are quite good at solving problems, generally speaking better, give them a problem to do and they love getting into it, but ask them to plan ahead but no way.* *SStaff4, Jan 98*

*…different attitudes to risk …seen it amongst female project students and research students… I don't think any difference in ability, but … whereas male students gone off and done things absolutely dopey, up the wall, catastrophic, dismissed this as… when female students have done that it had a more stinging personal impact*
*SStaff1, Oct 97*

Two senior male staff suggested that male students had a higher level of commitment in project work than their female peers:

*Some of the males have an intensity that is quite extraordinary …I have never seen the same level of intensity with women – it is a kind of total commitment to what they're doing at the moment…The women seem to like a more balanced diet, they work hard, but they like a more balanced diet.* *Dean1, Oct 1997*

*…the guys really shine at project , and they really get stuck in, they go for it and they really chase it around.* *HOD1, Jan 98*

I found these kinds of suggestions quite worrying, as they appeared to value an operational style that gave total, obsessive commitment to a project rather than a balanced management of time. Such comments confirmed my observation that some male staff had expectations of total time commitment to projects with time spent out of sight, working at home, not as valued as time spent in the labs. I heard the comment, made by more than one staff member, "*girls want to have a social life*" used to imply that female students were not sufficiently committed to their studies. I found myself questioning whether masculinity was linked to obsession and lack of balance in this environment, or whether these staff members were merely identifying with students whose behaviour patterns were more familiar to them.

#### *6.3.2.1 Relationships with Liaison WISE*

In the previous section I provided data which demonstrated that understandings of appropriate gendered behaviours complicated staff-student relationships for female students. With an average of only one female academic staff member per department there was little opportunity for female students, compared to their male peers, to interact with a same-sex academic staff member. Female staff felt the burden of assumptions that they would provide pastoral care and take responsibility for affirmative action promotions, on top of their other academic responsibilities,

*You are the woman staff member, you go along to the Enginuity Day committee – that happened to … and this year I decided that if I was involved in all the enrolment things* *someone else could have a go. I don't think it is appropriate that it is just the women who get involved – it should be a collective effort to encourage women*

*Jstaff3, Oct 1997*

*I started a network of women students in our department, but no-one wanted to know about it. They thought their responsibility ended with providing the money for the orange juice and pizzas* *Jstaff4, Oct 1997*

Diversity amongst women staff and students, both ethnic and personality type, meant that assumptions could not be made about the compatibility of same-sex relationships.

*The lack of women, particularly in our department, sees many women going to one in particular just because she is a woman. This has actually been downright destructive for one or two. A successful woman is not necessarily understanding, nor a good role model,* *Diana, E&E new graduate 1997*

My presence as the Liaison Officer for Women in Science and Engineering was a source of support, advice and mentoring for female students. In interviews and on questionnaires I asked students and staff to comment on their own experiences and perceptions of my role. My records showed that during any one year I was likely to have personally interacted with less than half of the female students but comments such as the following demonstrated that my presence was a contributing factor to the retention of female students.

*the role of Liaison Officer is a very valuable one for both recruitment and retention. The retention issue is one that should never be ignored because I think it is irresponsible to recruit women deliberately and then not offer them some support once they arrive. …….Just seeing that the School has you there gives people a message that the School is committed to the idea of women being a part of it*

*Rose, new graduate Eng Sci 1997*

*I came and saw you, near the beginning of my time at University when I was a bit more unfamiliar and I didn't know people as well as I do now. I feel maybe the females have advantage because we do have you.* *Chloe, 4th year Mech, 1996*

*It is also important that woman in the school have someone to turn to with any male related problems, as they can be unique and uncomfortable to talk about with men. I imagine this would not be unique to woman – I'm sure other minorities would also find this helpful……* *Diana, new graduate E&E 1997*

*felt that it was important knowing that you are there even if I didnt need you. …… if someone has a problem everyone says "go to Liz".* *Heather, 4th year E&E, 1996*

Although most staff members attributed the increase in female participation to better knowledge and understanding of engineering, changing community expectations and affirmative action events such as those organised by Liaison WISE, more than one staff member directly attributed the increase to my role as Liaison WISE.

*Not much would have changed without someone such as yourself*
*Questionnaire EE staffmember 1997*

In this institution, still numerically very male dominated, the Liaison Officer for Women in Science and Engineering was perceived as supporting and mentoring female students.

### 6.3.3 Student – student

As mentioned earlier in 6.2.2, the high value and importance of friends was a common theme, together with workload, that was repeated throughout all questionnaires, interviews and conversations with students.

*The best thing about the course was the people you met and the friendships made*
*Questionnaire M27, 1997*

*What do I remember most about my degree, well it would have to be the friends, many of them will be friends for life* *Geetha, 4th year E&E 1996*

When students entered at first year a very high proportion of them still lived at home under the influence of the family culture and were able to maintain pre-university friendships. For those students coming to the city from rural backgrounds or from overseas, the transition was not as speedy or as smooth:

*It wasn't that uncommon to hear crying in the hostel those first few weeks*
*Richard, 4th year E&E 1996*

*I was a bit scared, too many people I don't know. I don't know what to expect from the lectures and everything. High school and university is totally different*
*Teresa, 1st year 1998*

The students came from a very diverse range of ethnic and socio-economic backgrounds, so homogeneity of personal values and attitudes was highly unlikely, but in their first year, students appeared to make task-oriented friendships relatively easily:

*I think it takes time to build up friendship things. The first step is to have that academic friendship and it develops from there.* *Brian, 1st year 1998*

*Everyone just wanted to belong somewhere in engineering and it was easy because everyone else was looking for friends* *Maya, 1st year 1998*

Students were in the company of their peers for at least six hours a day – studying and working on similar problems. As their degree progressed, this contact time often increased, with long hours spent in computer labs or working on projects together. It was likely that close relationships would form and several aspects of these relationships have been referred to elsewhere. I have discussed the behaviours and practices associated with an almost total physical isolation from the rest of the campus in section 4.4 and with student social events in section 5.5.5. The perceived necessity for supportive task-oriented relationships I referred to earlier in this chapter in sections 6.2.1 and 6.2.2.

As I explained in the previous chapter (5.5.5) the stereotypical behaviours still attributed around the campus and in the community to engineering students were not applicable to the majority of students in the late 1990s. These students did not see conformity to any social type as an essential component of their identity as engineers.

> *I think there is a culture in terms of "I am an engineer" and the way of thinking in terms of an academic attitude …but on a social level there isn't a distinctive social type, there is a distinctive thinking type* *Angus, 1st year 1998*

The students identified as engineers with pride and a sense of belonging which went as far as "family" for some students, as these comments indicated:

> *The diversity of individuals within the School coexists with a very strong sense of identity (among students, at least). By this I refer to the pride with which students profess to their course of study, and the sense of community exhibited upon contact with outsiders. The common bond of "being engineers"* *Laurie 1st year 1998*

> *Engineering has a special and valued identity. It is "I am an engineer" based on getting a job, working harder (ignore the existence of med and law students), it's a hard degree* *Trish, 3rd year Civil, 1997*

> *… there is a feeling more of a big family and it is perhaps a little easier to relate to an engineer than someone with a BTech or another student.* *Karol, 4th year C&M, 1996*

Those students who spoke most positively about belonging and friendship, also spoke of strong, united class groups.

#### *6.3.3.1 Class groups*

Three years spent with the same group of students, whether it was the smaller classes of Chemical and Materials Engineering and Engineering Science (around 30-40 students), or the larger classes such as Electrical and Electronic Engineering (approximately 100 students) provided the stability that enabled relationships to form:

> *I had many friends outside in the first and second year but in third and fourth year you had no time to go outside. We had all our meals here, do everything here, even sleep*

*here sometimes, so your friends become your classmates… you work together and you see that they help each other. Really strengthens relationships.*

*Mei, 4th year E&E 1996*

I found considerable variation and little predictability in class relationships from year to year, and from discipline to discipline. Sometimes the students identified their whole class as a close group:

*You are all in the same boat, heading down the same direction, you all did the same papers until the last year …Develop good relationships with them*

*Samuel, new graduate Civil 1997*

*…we probably had the best class you could imagine with everyone getting on really well* *Questionnaire M20 (C&M)*

*You make a lot of close friends especially in engineering science – you have the same 20ish people with you in every single class and every single tutorial You make very close friends.* *Dave, 4th year Eng Sci 1997*

*…our class being so small we are all good friends There are a couple of people who don't fit in quite so well but they are still accepted.*

*Amanda, 4th year Eng Sci 1996*

Whereas in other classes, students were more inclined to cluster in groups within the class, with some students not finding a close group:

*Our class is very segregated very groupy – like Hong Kong group, or the Malaysian group – mainly yeah you talk to each other when you need help with assignments but socially – not that much.* *Amy, 4th year E&E 1996*

*…found it difficult to find "true friends"* *Questionnaire F6 (E&E)*

When students failed courses and had to repeat the year or returned after a break, I observed that their academic progress was often impeded by the difficulty they had breaking into the stable friendship groups which appeared to be so necessary for academic support. This difficulty was manifested, for example, when a new student tried to find a compatible project partner or partners after selections had already been made, and the perception was that those left over were the "rejects".

I concluded that if belonging was an important part of the culture, then it was likely that students who might be marginalised or seen as "different" would have difficulties in being fully participating members of the culture. I have therefore analysed the relationships students formed, across and between genders, for their potential to affect the ability to 'belong'.

#### *6.3.3.2 Relationships and gender*

All-male groups were so common as to be the norm, whereas all-female groups of students or staff, either informal or formal (as in WEN) were not only rare but sometimes seen as divisive and almost always provoked comment such as "*I hope I am not interrupting anything*" or "*are you having a girls day out*?". These were innocuous and probably well-meaning comments, but symptomatic of the "otherness" implicit in an all-female group within engineering.

I observed that quite a large proportion of the female students mixed comfortably with their male peers, but often moved around in stable pairs or threesomes which appeared to be quite tight friendships. Whether this was a support mechanism, as this comment suggested:

> *I don't know but I think having known Sarah and Heather and hanging round with them I felt a lot more confident because of belonging to a group …if there is three of you it is much easier to go and talk to a bunch of guys because you have got the support of the other people being there* *Miriam, 4th year E&E 1996*

or simply a preferred socialisation style, the result was that it was rare to see a female student who was consistently a "loner".

Being female students in the same class did not, however, automatically mean having common interests or that a lasting friendship would form as these comments illustrated:

> *I couldn't say that the girls in my class did stick together, two of them were good friends …most of us weren't a clingy group but we were quite able to go and talk to each other.*
> *Chloe, 4th year Mech, 1996*

> *But I guess in the end we're all pretty different, with different interests and situations, so I couldn't really say I formed 'close' friendships with any of them. …I do think that is a thing about university. You are thrown into often quite close situations with people you would never have anything to do with normally.* *Helen, new graduate E&E 1997*

I regularly saw instances where a female student associated more closely with male students than with other female students in her class and several female students commented that they liked the company of male students, preferring their company to those of females:

> *I've always got on well with the guys, and I've sort of been closer to the guys in my class than the girls* *Chloe, 4th year Mech 1996*

> *…socially I have enjoyed being back in with the guys after my school where you get used to being around girls. Now I am totally used to being around guys I found them much easier to get along with.* *Amanda, 4th year Eng Sci 1996*

On occasions some female students found themselves isolated in a class or tutorial where they were either the only woman or the only woman without a natural friendship group. An example was a first year female student, of Chinese descent but raised in New Zealand. In her Design tutorial she felt isolated from the dominant male NZ European group and the Cantonese-speaking Chinese group. This caused her, and other students like her in later years, enough discomfort to seek a change of tutorial class.

A large number of female students did not participate in the Women in Engineering Network and saw it as divisive because it discriminated on the basis of sex and appeared to imply weakness or the need for support:

> *I used to go to the WEN lunches at the beginning but as I grew in confidence I sort of stopped coming – they are definitely a good idea at the beginning at your time at university when you would like to get together with some people, some females. Going to a meeting with other females is not sort of a threat – you feel it is easier for you to walk into a room of strangers if they are all female – you know you are going to be all right sort of thing* *Chloe, 4th year Mech 1996*

> *Not for me because I had an awesome group of friends, but for females who are more isolated it is a good idea for support* *Questionnaire F4, 1997*

Other students welcomed the interactions with other females in what was usually a male dominated environment:

> *WEN helped me make friends, especially with other years, you don't often mix with people from other year.* *Jaya, 1st year 1998*

> *…fellowship of women is positive. Some issues need to be discussed in a women only forum (such as sexism in the workplace)* *Questionnaire F26, 1997*

Only a few male students appeared to accept WEN as "just another social group" without a sense of division or viewing them as needy.

> *I thought it was a really good idea, I know some of the guys thought it was stupid or whatever but that is bit ignorant, a bit of a knee jerk reaction, I think it is good especially when they are a minority.* *Brett, 4th year E&E, 1997*

> *No problem having WEN. Me and my friends have gone 'mutter mutter'. Good if programs existed for guys as well, going into engineering guys don't know …*
> *Richard, 4th year E&E, 1997*

I had a sense that comments by the male students interviewed or surveyed for this research were honest, but tactful and less emotive or extreme than they would have been in an informal setting with their peers. I was aware of resentment by male students to, what was seen as, "special" treatment for women in the way of events and the position of Liaison WISE. This was demonstrated by the formation of BEN, the Blokes in Engineering Network, in 1998. BEN was shortlived, mostly rhetoric and did not ever hold any events, but what was noteworthy was that it formed at all, and that, although its membership was predominantly male members of AUES, it also included some female students.

There appeared to be little visible backlash or negative attitude to the ethnic student societies, compared to that observed (covertly if not overtly) with WEN. It seemed as if all the diversities amongst the male students were forgotten in their united "maleness" when a group of women were gathered together. Feelings and emotions around gender appeared to be based on very deep-seated beliefs and assumptions:

> *They have kind of an attitude about WEN …they think it is this kind of feminist group …What I have heard from quite a few guys is that, you know, there is no need for it and it shouldn't really exist …they accept SPIES …because it isn't a gender thing*
> *Chloe, 4th year Mech 1996*

Relationships between the sexes appeared predominantly comfortable and relaxed. Although at least one student perceived that male students *"see you as a person, they didn't think of you as a girl"* (Geetha, 4th year E&E, 1996), some of the female students interviewed recognised the existence of behaviours or boundaries that enabled male/female relationships to occur without "complications":

> *It depends entirely on your body language – my friends like … most of the guys in my class I have never had a problem with them, because I guess it is quite clear that I am never going to go out with them* *Karol, 4th year C&M 1996*

> *I think I must have an understanding with the guys in my class and we just know that we are mates and there is really no other interest there.* *Chloe, 4th year Mech 1996*

From time to time, these boundaries would be exceeded, usually by inappropriate comments, and female students appeared to me to be either tolerant or reluctant to take action until a situation became quite unacceptable:

> *I've had harassment in the fact that one of the guys in my class was sending me really annoying Email messages about going to the movies and stuff …I guess it is all in the way you deal with it, and most of the time, I was just polite but yeah, I think he was doing it to a couple of the other girls as well but yeah, it sort of went on all year and I just ignored them* *Terri, 4th year Mech 1996*

> *…one of my classmates from the middle of last year he has gone mad and stalking me around… you don't feel safe at all, you can't even stay late at varsity and do work …I thought it was just infatuation and he would probably get over it, but by the end of the year it was quite bad so I actually did report it .* *Mei, 4th year E&E 1996*

> *Any problems are a few morons – they don't think. Students are so young, they've never thought about women's issues, so put downs exist. But we put the blame onto the moron who makes the comment or does the action.* *Trish, 3rd year Civil 1997*

At a time in their lives when, as one lecturer expressed it, "*testosterone is rampant*" (HOD1, Oct 97), an awareness of their sexuality for both male and female students appeared to me to be ever-present but sublimated temporarily under the academic pressures. As noted in Chapter 2, other authors (Holland & Eisenhart, 1990) had suggested that the influences of romantic relationships impacted on academic progress and growth. I found ample evidence, predominantly in informal discussions as a trusted confidante, of academic growth and success sometimes enhanced, but often disrupted, by the formation and dissolution of romantic relationships. Female students appeared to be wary of forming relationships within their own class, and one explained "*it would be like dating your brother*", but there was also the awareness of gossip amidst the close proximity of the class groups. Female students appeared to be particularly vulnerable to gossip and potential confusion of roles, as these comments illustrated:

> *She had both friendship and sexual relationships with some of the guys in our class and God that makes things awkward …One is OK, two yeah, but three …you have got a reputation and you are no longer the credible engineering student*
>
> *Melanie, new graduate E&E 1997*

> *…females go out with say 3 or 4 engineers – where they might have gone out with 3 or 4 other guys but no one would know …here everyone would know they have gone out with those 3 or 4, and I know that has reflected very badly on the females …I can think of two or three females that a lot of guys talk to them, very happy to think of them as potential sexual objects but not happy to think of them as anything else and that is a shame*
>
> *Karol, 4th year C&M 1996*

For female students of any background, their ethnic affiliation, with its implications of similar family and educational values, appeared to be a stronger influence than their feeling of connection or similarity as women. Mei was a Malaysian Chinese student who commented in her interview that in her Electrical Engineering class she identified more easily with her Malaysian friends, both male and female, than she did with her Kiwi woman friends:

> *I find that the female students – lot of them have boyfriends …they are quite cliquey with their own Chinese groups …I think some of the Chinese think because there is already Malaysian and Taiwanese students associations on campus they go with them.*
>
> *Mei, 4th year E&E 1998*

Male students also appeared to only "see" females of their own ethnicity – I was startled to hear Brett (4th year E&E 1997) comment that there were only 3 women in his class, when my records showed there were actually 8. Similarly Richard (4th year E&E 1996) also commented that there were only 3 women in his class, when my records showed 22! In both cases these young men were of NZ European background and they could only recall or "see" the young women who were also of NZ European ethnicity.

In the large classes, such as Electrical and Electronic and Mechanical engineering where female students were in much smaller numbers, they were more likely to form relationships with male students of their own ethnic and educational background than to necessarily connect with another female student.

Relationships were clearly important to the students, both for academic success (as described in section 6.2), and for social integration and their sense of belonging. My observations and the evidence provided by students themselves demonstrated that, although they were strongly aware of the gendered identities of their peers, amongst so many other diversities, gender was often seen as "*just another difference*".

> *Ethnic origin, background and school, maybe gender… yeah it is just another difference… one of the diversities. It sort of, the diversity of the class kind of makes the differences between guys and girls fuzzier, I found very few….* *Brian, 1st year 1998*

I have inferred from these findings that both academic and social integration, demonstrated by the existence of a task-oriented friendship group, were very important for successful academic and personal outcomes. The nature of this friendship group appeared to be relatively unimportant, be it same-sex or mixed sex, based on a common ethnicity or educational background, but its existence was critical. To be a loner, outside of these supportive relationships, appeared to impede academic progress and growth towards a confident self perception of identity as an engineer.

## 6.4 Language

One of the definitions of language in the Collins English dictionary (1994) is "the specialised vocabulary used by a particular group". Engineering education, in common with most disciplines, has its own jargon and terminology and ways of conveying meaning and understanding. In this section I will look at language as moving beyond traditional textual vocabularies to a variety of modes of communication in the cultural context of engineering education.

The goals of the new curriculum (5.2.2) recognised the professional need for engineers to communicate well with a wide range of people, including management, other professionals, tradespeople, contractors and the community. Communication skills are commonly linked to writing and speaking and the ability to understand and share meaning through these means. Considerable time was given in the curriculum and teaching practices (as outlined in Chapter 5) in recognition of the importance of those skills.

### 6.4.1 Engineering has its own language

In the disciplinary context of engineering, the written and spoken language appeared to focus on logical directness and order rather than opinion, argument or ideological reflection. Writing succinctly, "to the point", in as few words as possible was seen as desirable as these comments illustrate:

> *If you are preparing a discussion paper for the meeting tomorrow, keep it short and sharp, no more than two pages and use bullet points.* *Staffmember, Diary, May 1998*

> *I think engineering school is very analytical, par for the course, language style is also that way inclined, very specific, get straight down to the point, no furry bits on the outside – on the whole because you have a lot to get through, no room for any extra talk about whatever – straight to the point* *Kerry, new graduate Civil 1996*

> *The engineering school vocab is more direct and it almost always gets related to stuff we are studying, like at the moment if something is happening between two people, there is an analogy to the currents or magnetic fields, and last semester it was moments and couples…* *Barbara, 1st year 1998*

In common with other disciplines, Engineering had its own jargon, vocabulary of technical terms, as well as Engineering-specific meanings for otherwise common words e.g. moments, couples, stress… Students sometimes found the jargon and technical terms isolating and difficult to use when explaining their work to family and friends:

> *F… told me she chose to do a particular final year project – to study how tumours can be treated by controlling the electronic field – because it was something she could easily explain to her family and friends… if she told them 'I am learning linear systems or doing Fourier analysis' – their eyes glaze over and she felt like an alien.*
> *Jstaff4, Oct 97*

Assessment examples quoted in section 5.3 illustrated the dense nature of the engineering technical jargon, and its need for a very specialized vocabulary. Without an understanding of the appropriate terminology questions were often meaningless.

An example of specific usage, was the use of the term “analyse” which in engineering carried with it the implication that analysis would involve mathematics, fundamental science, abstraction and perhaps modelling rather than a textual reflective process.

> *In engineering it is a specific kind of analysis, something technical…like ‘perform a Hardy Cross analysis of the pipe network shown below’ – that means you have to quantify losses and work out exact flow rates and calculate the pressures etc… Whereas in English literature – a ‘close analysis’ means analyse the language, the form as well as the function – how does it do something rather than just what it does … and a ‘critical analysis’ of one of the following passages means paying close attention to the style of the passage, the imagery, vocabulary, syntax, metre, and rhythm.*
> *Rebecca BA/BE conjoint student, 1st year 1998*

> *Critical analysis comes in – part of what they have to do is understand what is being asked to be done… Then trying to understand the underlying science – requires investigation and how others solve the problem, the pros and cons of each method and this is the critical part of it.* *SStaff6, Sept 00*

In addition to text based communication, written or oral, mathematics, symbols, and graphics of many kinds, were all integral modes of engineering communication. Whether it be in a lecture theatre, a project meeting or informal discussion group, both staff and students illustrated, demonstrated, and added to discussion, using a very visual approach that linked knowledge transmission and communication by a mixture of diagrams, graphs, flow charts and mathematics supported by, rather than built on, words:

> *Because of engineering’s relationship to physical things, you need to be able to represent them in some way – need some sort of abstraction to represent the problem and the desired outcome… need a way of describing or modelling more effective than words…examples might be free body diagrams, graphs and maths itself.*
> *Sstaff1, feedback June 2002*

Examples of assessment instruments discussed in Chapter 5 demonstrated that understanding was tested using this range of communication styles, indicated by terms such as calculate, determine, explain, predict, sketch, and plot.

Alongside other roles of mathematics which I have discussed in 5.2.6, staff recognised the use of mathematics as a language within engineering:

> *…we use maths like a language – a language to express ideas – so unless they can understand what the parts of the equation mean they cannot see how it can be manipulated and a higher level of understanding cannot be attained.* *JStaff4, Oct 97*

> *The maths is so much quicker than verbalizing – it is like a shorthand way of writing the interrelationship between sets of parameters…* *Sstaff1, feedback June*

For engineers, an equation such as that below is like a sentence with a clear meaning. It tells not only how to calculate one quantity from known values of others but conveys the inter-relationship between variables:

$$\frac{D\Gamma}{Dt} = \int_C \frac{dp}{\rho} + \int_C v.dv = \int_C \frac{dp}{\rho} + d\left(\frac{v^2}{2}\right)$$

The importance of this visual and symbolic language as part of the communication toolkit of engineers was reinforced by several staff members with comments such as these:

> *I ask my students, how many languages do you know and nowadays some of them know two or three – but I tell them they know more than that because they use maths and circuit diagrams and symbols and these are extra languages they use for communication…* *Sstaff1, feedback June 2002*

> *I always drum it into my students, draw a diagram. In tests and exams if they don't draw a diagram then they are penalised even if it is not asked for, because it is only if they draw it that you can tell where the forces are – it tells us they understand what the problem is.* *Sstaff10, feedback June 01*

A senior staff member commented that diagrams such as the circuit diagram reproduced below (Figure 6.1) *"are the lexicon of electrical engineering" (Diary, 28 Mar 01),* with students needing to be comfortable and confident using these diagrams to communicate.

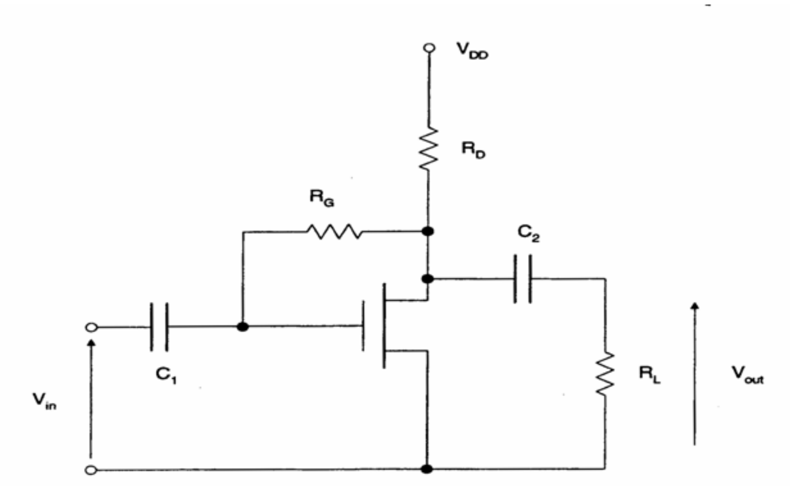



Figure 6.1 Circuit diagram from exam question

From these examples, I inferred that students learned how to communicate within engineering using the unique "languages" of engineering but would also need to recognise that they were likely to interact during their career with other professionals and lay people without the same "vocabulary".

### 6.4.2 Communication amongst staff and students

Amongst the staff, I observed a language style that was conservative, usually courteous in nature, often scattered with light joking and teasing, only rare use of swear words, rarely derogatory of colleagues except in jest, with few examples of displays of emotion:

> *Sort of dignity, you don't go round leaping around… if somebody gets a promotion they don't shout it from the rooftops or throw parties, it is just not done, it might reinforce it to someone who didn't get the promotion or grant. I think we are a pretty courteous lot*
> *Sstaff3, Sept 00.*

Anger, frustration and comments of a derogatory nature were heard in the common room, however, in discussions on the impact of decisions made by other parts of the university, particularly the central university administration.

Images of power and authority, with language often taken from that of sport, abounded in the informal talk between students and staff. Examples include those discussed in 6.2.1 under workload (such as "*hard yards*"), comments such as "*I really nailed that one*" on completing a test and "*we'll either be given it or we'll take it*" when discussing alternatives for a new building at a Faculty meeting. These are not unique to engineering, but I suggest reflected a masculine style common where large groups of males are gathered together. Their relevance to this study lay in the numerical dominance of men in the School of Engineering which made this language style likely to be prevalent and marginalising (or at least discomfiting) to those, usually females, who used a different communication style.

### 6.4.3 The dilemma of gendered language

Terms such as mankind, and chairman, are common in the English language and, after their long exposure to a world where an engineer could safely have been assumed to be male, I realised some staff found difficulty with change to more gender-inclusive terms:

> *We have discussed use of language as things have come up, at faculty level, although I have no memory of any directives or guidelines. There is just a heightened awareness – and individuals perhaps with raised consciousness. There are definitely efforts to be politically correct.* *Jstaff1, Jan 98*

> *It is hard to identify, but the major change is that at one time we just assumed that men did engineering and engineers would be men. I was looking through something I wrote*

*in 1980 and I saw it said something about " he" and it stood right out to me, it is not what I would say now… Dean2,Feb 97*

A large proportion of the staff had accepted the need be inclusive in their language, and made attempts to avoid language which might be deemed sexist or racist, but the consistent use of "he" and "his" was commented on by several students and recognised by staff:

*…"he" was prevalent …never used to notice that at all before I came to university and people used to talk about it and made you more aware of it… If they (the lecturers) were thinking about it they did make the effort but it wasn't unconscious, they had to think about it – this is not just engineering but society.*
*Peggy, new graduate Eng Sci 1997*

*Lecturers still use sexist language in that the welder, engineer, lawyer, client, customer are always 'he' in repeated examples. This makes us feel like we are not valid students or insignificant. Questionnaire F23, 1997*

A few young women, often slightly older than the rest, and with experience in other faculties, saw a danger in the constant use of one gender:

*It isn't actually fair. Any remarks of a sexual or gender nature, even the 'he, he, he' detracts from what you are trying to learn and sets the students into patterns*
*Trish, 3rd year Civil 1997*

Students recognised efforts by staff to be inclusive as "politically correct" – a term used in a way that carried with it an implied sense of compliance and lack of sincerity:

*I don't know whether we are doing things because they are seen to be correct or because we genuinely believe them. We have talked about colleagues attitudes to women, and how they surprise us…they are there still. SStaff5,Oct 1997*

*Our department is all very politically correct – but I am not sure they were totally sincere though Geetha, 4th year E&E 1996*

Male staff and students, who were typically not marginalised by gendered language, had difficulty seeing a problem with it:

*I think the political correctness has gone a bit way over the top …I see mankind as not excluding women at all – the term man doesn't just mean men, it means the whole human race. Dave, 4th year Eng Sci 1997*

*I don't worry too much about it. If it says "he" it doesn't really worry me, I never think of "he" as "he" – he just happens to be whoever it is. Sstaff4, Jan 98*

The male student, Dave, acknowledged, however, that the reverse situation would annoy him:

*I probably wouldn't notice if the lecturer consistently used the term "he" but I would if they used the word "she" all the time. It would get to me Dave, 4th year Eng Sci 1997*

Use of the terms girls, women and ladies was an illustration of the imprecision and potential for misunderstanding possible in the English language. On my arrival in 1989 at the university from a teaching environment, I called the female students “girls”, and several of the students emphatically told me they were “menstruating women” and not “girls”. When I, tongue in cheek, used the term “young ladies” at another function I was again reprimanded. “We are not young ladies!” Then, to make it more complicated, several female Asian students told me they didn’t want to come to a Women in Engineering lunch because using the term “women” sounded too aggressive. It was clear, that, at that time, the use of appropriate language was important.

As has been evident in many of the student quotations used in this study, both male and female students predominantly used the term “girls” rather than “women” when referring to female students, but I found subtle implications in the way these terms were used, as for example in this comment:

> *They’d realise one of us girls was sitting here, and they’d crack up and pull themselves back and you’d realise they were still seeing you as a woman – you couldn’t see why they should feel they should watch their language.*
>
> *Amanda, 4th year Eng Sci 1996*

The student referred to herself and fellow female students as “girls” (signifying non-sexual or pre-pubescent) and was surprised when she realised her male colleagues were seeing them as “women” (signifying sexual or post pubescent). Those few female students who used the term “women” rather than “girls” were usually older than the average, and had been exposed to feminist thinking, or women’s issues by prior educational or life experiences outside engineering.

For older staff, and those from other national cultures, the subtleties of gendered language were difficult.

> *The irony is a case very recently some of the female students were aware of being called ladies instead of women – but when I was that age it was derogatory to describe a female as a woman and lady was an appropriate form of address. I can see some staff would have difficulty.* *Assoc Dean, Jan 98*

A discussion in the tea room initiated by a lecturer asking me how to address the female students led to another lecturer who had first qualified in China, explaining that, when English was learned as a second language, a distinction was made between “ladies” and “women”. “Ladies” were the educated ones, with manners and knowledge of how to behave. “Women” were of lower status. We agreed that when students needed to be differentiated by sex to call them male and female students was appropriate (Diary 31 Sep 99).

There were no such difficulties with descriptors for male students and staff. It was common throughout the interviews to have students, both male and female, speaking about "*the guys*" and although sometimes the term was intended to be inclusive of a whole group, it was more common for it to signify the male students, with "girls" being the analogous term for female students. I interpreted a statement by a female student that "*I think they think of me as one of the guys*" – as implying a sense of belonging but also being accepted on male terms because in the next sentence the same student used the term "guys" referring to her male colleagues. Male students were referred to as "boys" by first year students who constantly use the terms "girls" and "boys", but in later years they were "guys", "lads" or "blokes" and "boys" was only used as a put down for immature behaviour. At no stage were male students spoken of as "men".

The term "bloke" – a colloquial term for male, was often used in engineering for the males who fitted the hard drinking, rough round the edges, stereotypical engineer, sometimes also known as a "lad". "*Blokes are proud of the drinking tradition*". The blokes and lads were commonly New Zealand born males who took part in the social events of the student engineering society and were a small group that made a lot of noise and had a high visibility:

> *A huge generalisation would be to break the school up into "blokes" (which does include some women) and "academic students".* *Trish, 3rd year Civil 1997*

The students who appear to be focused on study and who were not seen to socialise much were sometimes called "nerds" and "geeks" by their fellow students but these terms were not used often. Contrary to the cultural identities found by Tonso (1997) I did not find terms that appeared to apply specifically to engineering students, or had special meanings within engineering.

In New Zealand society, to call a boy a "girl" is a form of insult. Around the engineering school, the phrase "girl's blouse" was a derogatory term, which was usually applied to men who wouldn't do "lad" behaviour.

*When a guy does something wussy or girlie or something they get called a girl's blouse*
*Dave, 4th year Eng Sci 1997*

I noted that "wussy" which is rather untranslatable, but was best equated with "soft" as in "Don't be a wuss", was linked in the local youth culture with being a "girl". Once again that imagery of "soft", was linked with femininity, but more specifically, in opposition to masculinity.

### 6.4.4 Humour

Engineering jokes abounded and were commonly distributed via e-mail, cartoons posted on walls and in conversation. I have already quoted examples in the section on student publications (4.3.2) which aimed at reinforcing a sense of belonging and identity as an engineer by focussing on stereotypical male images, including alcohol, sexual and scatological innuendo.

In the public arena of lectures and tutorials, where diverse groups were involved, it was common for humour to be used with care that jokes did not target any one group, and with particular care for jokes that might be considered sexist or racist. Staff were aware, from past experience in the School, that Engineering had had a bad reputation for sexist joking and that offences would bring complaints.

It was, however, quite acceptable to use jokes that compared engineers with others, or to use personal self deprecatory humour.

Occasionally a staff member, particularly one who had been teaching in male dominated classrooms over a long period, would make a comment that would make female members of the class uncomfortable. I saw part of this discomfort arising because of the sudden reminder of their identity as "woman" intruding into a setting in which female students had considered themselves as (gender neutral) engineering students:

*One incident which really got on my nerves, was believe it or not, (male lecturer), a dear old guy, but one day in class he made a comment about something 'separating the men from the girls'. I think it was probably a slip of the tongue but of course the guys in the class thought it was hilarious* *Helen new graduate E&E 1997*

One lecturer, who was known to be extremely helpful and popular on an individual basis with all students, female and male of all ethnic backgrounds, found it very difficult to change a pattern of many years – put-down jokes were his way of getting the class "on side". Many students enjoyed his lectures but others recognised his humour as shaping students' attitudes and unnecessary for the transmission of information:

> *Well, except for (male lecturer) and he does it to everyone, it is probably just his nature. It is just his jokes and the way he tries to get the class laughing at someone's expense*
> *Chloe, 4th year Mech 1996*

Only a handful of women had formally complained as Briar did:

> *He starts all his lectures with jokes, and the boys at the back just love it but I don't see what the contents of a woman's bathroom cupboard have to do with this course. He just doesn't see that if he can get away with those jokes then it is like he is encouraging the guys to put down women whenever they like.* *Briar, Diary August 2000*

On an informal level, with a group of young people who are predominantly young men, both the male and female students perceived an inevitability about the prevalence of sexist joking:

> *I don't recall any racist humour, sexist yeah, mostly it was joking – but some people get hard core and make comments like " women can't drive" …The odd bit from lecturers and they know they are addressing a predominantly male or completely male audience so they just kind of play up to it in a kind of us and them kind of way.*
> *Brett, 4th year E&E 1997*

> *I lived at the hostel for 2 years with some fellow engineering students. They knew they had to behave at the engineering school (well most of them did!) but when they were back at the hostel there were no rules. Their conversations would reveal their attitudes to women in general – not always great.* *Rose, new graduate Eng Sci 1997*

> *Yeah, there are still sexist jokes and some 'humour' but I join in as well, there is a side of me that has no problem with that* *Julie, 4th year Mech 1996*

Male staff, many of whom had worked and studied in almost totally male environments, were often unthinking about the use of sexual innuendo in their humour. Female staff members were broad minded and tolerant and rarely actually offended, but the humour struck a discordant note – a reminder of "otherness":

> *Just standard male humour, you still hear it up here …it is like all classic traditional jokes about blondes …it is the male bonding sort of stuff – BD comes out with that sort of joke and looks at me as if asking "well are you going to get het up…" but I have a policy of not responding…* *Sstaff3, Sept 00*

> *Because I am the only woman here some of the jokes I don't like, it is not necessarily sexist, it is a blokeish kind of humour that I don't like – I get really mad, I think, it is not that I don't have a sense of humour but these are things that get passed on as a harmless joke and it only sinks in when you're a minority there.* *Jstaff4, Oct 97*

These comments from staff and students suggested that, despite efforts to ensure that language and humour were not divisive or offensive in educational settings such as classrooms and labs, the same did not apply in informal social settings. I saw the use of humour in these settings by the dominant (male) group as emphasising a sense of solidarity and group bonding. This type of humour, my evidence suggested, had the potential to marginalise females and those of minority racial groups.

## 6.5 Understandings of gendered behaviour

From my observations and interview analyses I inferred that the behaviours and perceptions of students indicated understandings around masculinity or femininity which were changeable and dependent on context. These (predominantly) young people were, I recognised, exploring and developing their identities as men and women at the same time as they were developing an understanding of their identity as engineers. Traditional models of New Zealand masculinity were evident and highly visible from time to time, as I have discussed in other sections (student publications, events, classroom behaviour…) but the beer drinking, rugby-playing, "blokey" model of masculinity did not appear to be applicable to the majority of the male students in the case study.

Concepts of femininity appeared to be especially complex and subject to change. I observed a common perception that females who studied engineering were different from other females:

> *I get on well with the girls in my class but perhaps it is because a lot of the girls aren't like really girlie, girlie – not really into their looks… I am not saying that the girls here don't take care of what they look like but they are not fascinated with it and not preoccupied with men all the time. These people have decided they want to do engineering and they want a career.* *Karol, 4th year C&M 1996*

> *I just get on so well with all the girls in my class – across the disciplines as well – they are the type of girls that do engineering, they are not 'wilting flowers' or gonna cry about the broken nail – they just get on and do things and are intelligent, most of the time, and I mean, you can be female and feminine as well but not dwelling on girlish things like going shopping and that…* *Terri, 4th year Mech 1996*

> *I noticed, most of us girls, all have very similar lives, doing things. Instead of playing Barbie we have been playing Lego, and we don't like the colour pink or anything associated with girlie… like we wouldn't dare wear a ribbon in our hair unless we were having a strange off day. Perhaps that is why we get along so well. I like engineering girls better.* *Sue, 1st year student 1998*

I found it unclear whether this "different-ness" from other females was a cause or effect of being engineering students. Sue's comment implied different interests which might have led to engineering, but this was difficult to verify. The diversity in interests amongst the female students ranged across ballet, painting, yachting and hockey, but very few female students spoke of practical, "hands-on" hobbies such as electronics or boat building. So perhaps females who were potential engineering students were a subgroup amongst females, but still different from males. Rose had identified (6.2.1) that "*One of the things I liked about E women is their personal strength*" which supported my own perception that the majority of the female students displayed a strength of character and independence, shaped in part by the learning environment. Female students responding to the survey of graduating students in 1997 identified that they had "*improved confidence and assertiveness*" (F26), "*learned to stand on my own*" (F7),"*become more broadminded, confident and tolerant*" (F9) and "*learnt to stand up for myself, learnt about failure and success, how to gain respect and how to be self-motivated*" (F17).

Male students also spoke of their female colleagues as different from other females in ways that implied strength, and "being logical", qualities which were portrayed as masculine:

> *I think guys give them a lot more respect because they have made the decision to do this …they are quite strong people and they wont be pushed around anyway.*
> *Richard 4th year E&E 1996*

> *I think in this particular environment they have to be harder or appear to be more – what is perceived as masculine I suppose in terms of what they are doing, but that is more a product of well, all the lecturers bar one are male, so that is kind of a male dominated environment, so they have just got to adapt to that. You know. So maybe they are not being themselves…* *Brett, 4th year E&E 1997*

> *…some are as feminine as an arts student and then there are some who aren't. To get into engineering their maths and science must be pretty good, and they must be logical thinkers and that is probably not the norm for women.* *Dave, 4th year Eng Sci 1997*

This "different-ness" from other females was also suggested by Lips' (2000) study, discussed in Chapter 2, in which she reported of female U of A engineering students:

> *Women who choose engineering and remain on that path long enough to take senior level courses, have a different sense of their own strengths and possibilities than other college women do.* *Lips, 2000*

Some female students articulated the long term effects of a predominantly male environment:

> *I tend to find it easier to relate to men than women now, and I don't think it was like that before, I mean I went to an all girls school but now I find it easier to relate to males. So I think it kind of occurred during my time at engineering school because there hasn't been that many females* *Kim, new graduate Civil 1996*

The female students appeared to see themselves as confident, independent and able to assert themselves in male company, but adamant that they were feminine and women, just not “girlie”. They used occasions such as the Ball to display their sexuality, and assert their femininity:

> *…there were always the engineering functions – and then all of a sudden you became a sexual object again, and they were things to look forward to for that. All of a sudden you could go and have guys flirt with you, and you could flirt with guys, even other engineers.* *Sophie, new graduate Civil 1998*

I found evidence that some of the skills and attributes needed in the standard teaching practices of engineering were perceived as masculine. For example there seemed to still be an assumption of the practical skills that McIlwee and Robinson (1992) called “tinkering”:

> *I see most of the female students in the academic role rather than the practical. In my mind I see two types of engineers. Those who can look at something and understand what is happening and those who can sit down there and do all the analysis and do all the maths and it is very rare that those are the same person …I don’t think I have ever seen any female who I would consider the practical sort*
> *Richard, 4th year E&E, 1996*

> *I think the guys had, most of the guys – well sometimes they get to know a lot more about little things than the girls do, like little things like computer architecture and hardware and lots of little things like that, that they know about. I think the girls aren’t quite as familiar with those sort of things.* *Mei, 4th year E&E, 1996*

> *There are guys out there that don’t know as much as you, but they’ll get called dumb whereas… you’ll be called a dumb female sort of thing, as if its because you’re female that you don’t know…* *Terri, 4th year Mech 1996*

My perception, spoken of elsewhere (5.2.5, 5.3.1.2, 6.2.6) was that female students were not alone in being disadvantaged by a lack of tinkering and practical experience, but those students advantaged by appropriate experience and background did appear to be overwhelmingly male. The norm, therefore, was for strengths in practical, engineering related skills to be associated with masculinity.

In a first year class of 1998, with 100 female students and 400 male students and diverse ethnic, educational and socio-economic backgrounds, the students’ comments evidenced their early perception that a range of gendered behaviours was acceptable, with none taking a dominant position:

> *I sort of thought you might have to be an honorary guy, but its not like that. You sort of expected that in some ways …and you don’t which is so good*
> *Shelley, 1st year student 1998*

> *I came from the Navy where I had to be a bit blokey and I could relax and be a girl at University and I thought that was pretty cool, I feel like I am a chick again*
> *Jane, 1st year student 1998*

After first year however, several disciplines such as Mechanical Engineering had very small numbers of female students and the change was noted by Jaya:

*Second year is different, it has become even more apparent how much of a minority females are in engineering when you can count the number of females in your class on both hands. Half the males in my class still haven't realised that females are human too.*
*Jaya, email communication, April 1999*

Despite the comments from the first year students who had suggested it was not necessary to be an honorary "guy", it appeared that, by the end of their fourth year, they had been largely enculturated. The following comments articulated and confirmed my observations over this research, and supported by data in earlier sections, that for most female students, to be mainstream was to be one of the guys:

*If I don't think about what it means to be a woman in this environment, then I can just be an engineer – one of the guys.* *Chloe, 4th year Mechanical 1996*

*There were 5 or 6 girls in my class – I got to know them very well. They were one of the boys – They were integrated as much as the rest of the class*
*Samuel, new graduate Civil 1998*

I did not set out to collect evidence around issues of hetero/homosexuality, which I judged to lie outside the scope of this study. Those women students who, over the years of the study, disclosed a homosexual orientation to me in my employed role, implied that they had experienced no discrimination or comment. They believed, however, that this was due to a combination of their own discretion and that of their colleagues: "*I keep my private life private, and if anyone suspects I am different they are not making an issue of it" (Diary,* October, 1999). This discretion appeared to be warranted, as I observed several instances where assertive female students taking an unpopular decision in student politics had their sexuality and parentage questioned, in a deliberately insulting fashion. The self-identification of male homosexuality was also absent from the public arena. I did not ask a direct question in interviews on the subject and it did not spontaneously arise, except in a feedback session with women students. They confirmed that no male engineering student to their knowledge had self identified as homosexual and commented:

*I think most of the guys' jokes and attitudes display quite homophobic attitudes*
*Rebecca, feedback, April 2000*

I inferred that in this culture, in which the behaviours I have reported on emphasised particular models of masculinity and the importance of belonging, acknowledging a homosexual orientation would be perceived as jeopardising acceptance and would therefore be a very private matter kept completely separate from this working environment.

## 6.6 Summary of cultural values and norms from Behaviours

In this chapter I have examined Behaviours, the third sub-level within the observable and tangible manifestations of the engineering education culture. In Appendix 15 I have provided a detailed tabulation of cultural values and norms inferred from Behaviours, the second level of my cultural analysis, cross referenced to those sections in this chapter which evidenced their manifestation. From this detailed analysis it became clear that behavioural norms around three themes have dominated my interpretation of Behaviours as responses to the academic and social environment. The three themes are: the effects of the "hard" or "challenge and stretch" teaching paradigm; the importance of friendships; and a strong sense of pride and belonging as an engineer. A summary of the behavioural norms around these themes is presented below.

### 6.6.1 Behavioural norms relating to the theme of "Hard" or "Challenge and stretch".

My data evidenced that teaching and learning in engineering took place in an environment that continually challenged and stretched students' preconceived limits. Illustrative comments and examples quoted in 6.2, and cross referenced in detail in Appendix 15, demonstrated that cultural norms for students were:

- To work under pressure with tight time constraints;
- To equate learning with shared hardship; and
- To view the "hardness" of the degree with pride and reflected glory.

I use the term "reflected glory" to refer to the students' rhetoric of how "hard" the degree was and their consequent sense of self worth in achieving and completing something "hard".

From the evidence provided in 6.2.3.3 I inferred that a cultural norm for staff was:

- To value the ability to "challenge and stretch" students as a pedagogical style.

I have argued that there are gendered implications in the use of “challenge and stretch” as a method of teaching. In Chapter 2 I referred to the likelihood of differing socialisations for male and female students. Since childhood, boys had been encouraged to take risks, not to cry and be “tough” which was not the case for the majority of girls who were used to a more nurturing style. It was clear from my conversations, interviews and observations with both students and staff that many female students were uncomfortable, initially at least, with this pedagogical style (6.2.3.3, 6.3.2). I saw a particular need for students to be explicitly reminded that the process of “challenging and stretching” was intended to give them opportunities to grow and extend their potential, rather than a “weeding out” of the unfit or leaving them to “sink or swim”.

Complementing this perception of engineering as “hard” was another cultural norm manifested by the data in sections 6.2.3.1 and 6.2.5.1:

- For students to adopt surface approaches to learning, with a “go for grades” attitude.

I observed a contradiction in explanations by staff and students for this norm. Staff espoused the value of students’ learning for understanding (as discussed in Chapter 5), but they perceived that students, in both learning and assessment situations, demonstrated a very instrumental approach to their studies (ref 6.2.3.1). Students, however, commented that although they would have liked to go into greater depth on some of their topics, they perceived that the intensity and volume of the workload did not permit this. I inferred from my data that there was a strong relationship between the practices of teaching and assessment and the student’s instrumentalist attitude, even allowing for the influence of external factors such as the rising level of tuition fees.

Running throughout student experience of this challenging environment was the norm that:

- students co-operated in order to compete.

Co-operation in both formal and informal groupings appeared to be a common behaviour, driven in some cases by the individual imperative to get a group outcome (6.2.2, 6.2.6), and in others by a need for "survival" and "support" (6.2.4). Informal cooperation, and camaraderie was enhanced by the close interactions of crowded classrooms (6.2.5.2) and the sense of shared "hardship" (6.2.1) spoken of earlier.

The literature to which I referred in Chapter 2 had identified that femininity and female socialisation patterns were associated with co-operation rather than competition. I found some evidence that female students manifested co-operative behaviour more than their male peers (6.2.2), but this behaviour was gender-related rather than gender-specific. The majority of students, both male and female, valued opportunities to study and learn in groups.

The combination of the perceived "hard" workload, and "go for grades attitude" appeared to have resulted in the cultural norm that:

- Copying and sharing of assignment solutions was common.

There was a tension for students between the valuing of co-operation and teamwork and an instrumentalist attitude of "going for grades". The level to which "sharing" or "inappropriate co-operation" took place, and came into the category of cheating, varied (6.2.3.2), but for some students the value of assignment completion and acquisition of passing grades clearly took precedence over personal integrity.

Contributing also to the understandings of engineering as a "hard" discipline was the dominance of shared understandings around language within engineering of the norm:

- Mathematics was used as a language, with its own vocabulary and meanings.

In Chapter 5 I commented on the pervasive use of mathematics within engineering to access and demonstrate knowledge and understanding, but in this chapter I have stressed its use, together with an extensive "vocabulary" of visual images and symbols, as a language for effective and efficient communication (6.4.1). This language, I suggest, has the potential to isolate engineers from those outside the discipline.

### 6.6.2 The importance of friendships

The norm that:

- Students highly valued friends and friendship groups

was one of the commonest themes throughout this study. Linked to earlier comments on perceptions of workload (6.2.2), and co-operation as a strategy for academic survival (6.2.4), the importance of friends for social integration was particularly evidenced by the positive experiences and outcomes for students from close knit class groups (6.3.3.1). Three years of close interaction in some of these classes appeared to allow the formation of relationships which transcended social boundaries such as gender and ethnicity providing much valued interaction and support.

In the larger class groups, and in the student body generally, there was also evidence that common ethnicity and educational background were stronger drivers for the formation of friendship groups than gender. Alongside an awareness of "boundaries" in male/female relationships, I perceived female students as comfortable in friendship groups with either male or female students. Some female students formed close friendships with other women which lasted three or four years, but my findings supported the argument that the over-riding need was for the existence of friendship groups which provided academic and social support regardless of their gender or ethnic composition.

### 6.6.3 Pride and sense of belonging as an engineer

The norm that:

- Students and staff identified themselves with pride and a sense of belonging as engineers appeared to incorporate understandings around several of the themes that I have identified in this and previous chapters. A sense of shared survival of a "hard" degree and workload (6.2.1, 6.2.3.2), close friendships formed over three or four years of close interaction (6.3.3, 6.4.4), pride in a profession which "makes a difference", and a sense of belonging were epitomised in the comment:

> *Engineering does have a special and valued identity. It is "I am an engineer" based on getting a job, working harder, doing something practical and useful. Blokes are proud of the drinking tradition. The pride in being an engineer, combined with how much time you spend with classmates results in a family feeling.* *Trish, 3rd year Civil 1997*

Throughout all of the Behaviours commented on in this chapter it was evident that:

- To be male was the norm and to be female was to be "other".

The data I have presented in this chapter, chosen as representative of my body of evidence, supported my inference that the participants did not always regard this sense of "otherness" to be one of devaluing or lack of respect, but long habit and the traditional numerical dominance meant that masculine imagery, language, humour and behavioural style were cultural norms pervading all aspects of behaviour with indicative examples provided in 6.3.2, 6.3.3.2, 6.4.3, 6.5.

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This norm was particularly evidenced by the tacit understanding that to be "one of the guys" implied being accepted and belonging in the predominantly male group. Language and humour, I found, often brought a "jolting" awareness for the students of their dual roles – as women and as engineers (or engineering students). For female students, a sense of "visibility" as females within the larger male body did not initially appear to be evident amongst the diversity and anonymity of the large first year classes. From my own observations and the reflections of staff and students (6.5) I posit that female students' awareness of their visibility was heightened as they moved up the School causing them to increasingly adopt behaviours which would allow them to blend in with their peers, as "one of the guys". A sense of "otherness" for female students also extended to the norm that:

- Female engineering students were perceived as "different" to other females.

This perception was linked by both male and female students to implications of personal strength and ability, with a denigration of definitions of femininity which might imply "softness" and "girlieness"(6.2.1, 6.5).

In this chapter I have presented my findings relating to Behaviours, the third perspective from which I have sought evidence to answer my first and second research questions. I used the voices of the participants, added to my own observations, to go beyond the behaviours visible to an "outsider" and allow the shared tacit knowledge and understandings of appropriate behaviours within this setting to be explored. From this evidence I have interpreted values and cultural norms, listed in detail (Appendix 15) and grouped, in this summary, around three strong themes: firstly, that engineering is "hard"; secondly, the importance of friends; and thirdly, the strong sense pride and belonging in their identity as engineers. Weaving through the behaviours in this chapter were my findings on gendered behaviours and their implications, concluding with the truism, that within the case study institution, to be male was the norm and to be female was to be "other". Also woven throughout the chapter, in answer to my second research question, I have included references to the learning processes as students developed behaviours which enabled them to succeed academically and adapt to prevailing behavioural norms.

Incorporating my findings from this chapter and the two preceding chapters, I now move to the third level of my analysis of the culture of engineering education, my interpretation of the beliefs and assumptions which my theoretical framework proposes as the essence of culture formation and maintenance.

# Chapter 7

# The culture

## 7.1 Purpose and outline of the chapter

The purpose of this chapter is to provide the third level of my analysis in answer to my first and second research questions. In keeping with the model of culture that I proposed in Figure 3.1, I begin by synthesising my findings of the shared values and cultural norms identified in Chapters 4, 5 and 6, listed in detail in Appendices 13,14 and 15, to expose and focus on the shared beliefs and assumptions that lie at the third level of culture, which I argue is the core or essence of the culture. I identify seven cultural dimensions around which these shared beliefs and assumptions have formed for engineering education. In so doing, I both answer my first research question (What are the dimensions/elements of the culture of engineering education in the case study institution and how do they interact with gender?), and provide a definitive study of the culture of engineering education, the lack of which I highlighted at the outset of this study.

Following my synthesis of the dimensions of the culture, I consider the second part of my first research question by looking at the ways in which the identified cultural dimensions and their associated values, beliefs and assumptions are gendered. I leave the second part of my exploration of the interaction of gender with the culture, the formation and maintenance of gendered identities within the culture, until Chapter 9, where I also discuss the implications of my findings for the participation of women.

In the final section of this chapter, I answer my second research question (How is the culture of engineering education learned in the case study institution and how does gender interact with this learning process?). Again, I bring together my findings from Chapters 4, 5 and 6, in this case focusing on the ways in which students learned what it meant to think, act, behave, and relate to each other as engineers. I use Figure 3.1 to frame my synthesis of these learning processes. Woven throughout my discussion is a consideration of the interaction of gender with the enculturation processes.

## 7.2 The dimensions of the culture of engineering education – Research Question 1

In answering my first research question at this third level of analysis I refer back to the model (Figure 3.1) that I developed, building on Schein's theoretical framework (1985, 1991), for the analysis of the culture of engineering education as experienced in this study.

My premise using this model is that the observable and tangible manifestations, and cultural norms identified in the previous three chapters have developed from basic beliefs and assumptions, as engineering educators and students sought to find their personal and collective answers to issues which Schein called "issues of external adaptation and internal integration". As described in Chapter 2 Schein developed his framework in the context of deciphering organisational culture. In applying this framework to my study of a disciplinary culture in a higher education institution, I saw the "issues of external adaptation and internal integration" focused around the following questions:

- What kinds of knowledge were valued? What was seen as truth? Was there a prevalent "way of thinking?"
- What was the relationship of the culture of engineering to the rest of the university and academia in general, the profession and community?
- What was the primary task – how was it to be accomplished – was there a "right" way to teach/learn?
- What was considered the "right" way for people in this culture to relate to one another?
- Were there attributes and qualities inherent in being "an engineer"? Who fitted in and was successful?
- Was it seen as desirable or necessary to have homogeneity or diversity in the members of the culture? How was difference accepted?
- How was time managed? Was the use of time seen as important?

Schein located the answers to these questions within cultural dimensions, the number of which was not fixed. In a discussion with Schein[1] he suggested to me that "the

[1] Personal communication, E.Schein, e-mail 14 Feb 2002.

number of dimensions you use… would reflect the depth of your analysis, a low number such as two would be very coarse and a hundred would be very fine”. I chose to use seven dimensions based on those used by Schein in his 1991 paper (Schein, 1991), but adapted to address the issues identified above for a disciplinary culture. I now examine in sections 7.2.1 – 7.2.7 each of the seven cultural dimensions that constitute the essence of the engineering education culture that I have seen manifested in the case study institution.

### 7.2.1 The Engineering way of thinking

In defining a disciplinary culture I saw one dimension of the culture encapsulated in how the following questions were answered: What kinds of knowledge were valued? What was perceived as truth? Was there a prevalent way of thinking?

My results have emphasised that, despite individual differences, there were shared beliefs and assumptions around these questions. These I named “The engineering way of thinking”. These beliefs and assumptions were rarely discussed. Rather, they seemed unconscious and taken for granted by both engineering academics and professional engineers.

The first of these was that engineering dealt with a tangible, definable, measurable, quantifiable reality. Valued knowledge was seen as relevant to real life. “What would we use this for?” was the justification for learning. I have provided examples in earlier chapters of abstract, philosophical concepts, such as ethics and sustainability being unacceptable to both staff and students unless taught in a practical, relevant context.

In this discipline, truth and reality were proven and described by mathematics. Is the bridge safe? Will the structure cope with an earthquake measuring 8 on the Richter scale? Can the functionality and efficiency of this product be improved without increasing costs, or losing quality? Mathematics was the tool and language by which these and other questions were answered. The shared set of understandings in engineering education, based on common knowledge and practice, resulted in comments such as this one (quoted earlier in 5.3.1.2):

*"The line (1) $\Sigma F_y = m\,a_c$ $200g - T_c = 200(a_c)$ in the model answer was as good as a sentence to me"*

The inextricably pervasive nature of mathematics within engineering appeared to be essential as a key to access, understanding and thinking like an engineer. As mentioned in Chapter 2, Beder (1998) and Hacker (1983), amongst others, have viewed and critiqued as "obsessive" the influence of mathematics within engineering education. The Australian review (IEAust, 1996) also commented on a lack of tolerance for the "non-quantifiable". These critiques recognised the assumptions around the importance of mathematics in the culture, but, taking my analysis a stage further than previous studies, I spent some time in chapters 5 and 6 deconstructing the role of mathematics and its use as a language, to illustrate how these assumptions are operationalised in day-to-day practices and behaviours.

The need to work with the definable and measurable was reflected in the prevalence, not only of mathematics and its symbolic language, but also the use of diagrams and graphics to communicate, rather than a reliance on words. Within engineering, even when using the written word, the emphasis, as discussed in section 6.4.1, was on logical directness and order, rather than opinion, argument or ideological reflection.

Secondly, the "engineering way of thinking " was focused around problem solving and design. As discussed in sections 5.2.5 and 5.2.6, problem solving was dominated by reductionist and top down methodologies – breaking complex systems down into separate modules, and often invoking mathematical formulae or estimation. Design, in particular, appeared to epitomise the essence of what staff and students believed to be the "engineering way of thinking" – that which made engineering distinct from pure or applied science. The engineer's role in developing optimal, innovative solutions to real rather than theoretical problems was a source of passion and pride illustrated by the value placed on Design courses and competitions (5.2.6). Design education introduced the concept of engineering as working with constraints and compromise, having to provide pragmatic, cost effective, timely and "best", rather than perfect, solutions to questions and problems that were rarely defined by engineers themselves. A basic assumption was that any solution <u>must</u> work; it could not be hypothetical. It must do the task specified, within the limits specified.

Again, in something of an advance on previous research, my study has highlighted the essential nature in the "Engineering way of thinking" of Design and problem solving. The philosophical, and reflective writings of authors such as Goldman (1990), Koen (1984) and Solomon (1997), mentioned in section 2.2.2, recognised Design as the essence of engineering. However, research from outside engineering such as that of Becher 1989) and some from the feminist critique (Lewis et al., 1998; McIlwee & Robinson, 1992) contained little, if any, mention of this dimension.

Thirdly, the engineering way of thinking appeared to accept that there were not always "right" answers. Much of the education process, especially the fundamental engineering science courses, assumed the certainty and indisputable nature of the formulae and knowledge underpinning analysis and the need for exact calculations in situations (such as calculating the load bearing capacity of a beam, or the aerodynamic lift under a wing). Open-ended problem solving was, however, an important component of the program at the U of A, as demonstrated by the commitment to problem and project based learning which I discussed in Chapter 5. Exact calculations on load- bearing capacity, for example, would be expected, but the choice of beam type might itself be a variable. Students would be requested for the "best" choice according to prescribed constraints such as cost, weight, materials, required load, and construction time. Appropriate mathematical techniques would be used to validate their choice. It was accepted that no two design solutions were likely to be exactly the same.

My data (at least for the early years of engineering education) confirmed Johnston et al.'s (1995b) observation that tasks and problems were constrained and well defined by the people formulating the problem. My analysis has expanded Johnston et al.'s view. I have demonstrated that, once problems and systems became more complex it was rare for them to be solved without making assumptions at problem- definition stage and judgements at choice-of-solution stage. Engineering was presented as dealing objectively with the measurable and quantifiable. It seemed to me, however, that assumptions and judgements carry with them a level of uncertainty and subjectivity that was rarely acknowledged but more often ignored or hidden behind the mathematics.

The focus on problem solving, and in particular the pragmatic necessity within an educational system to provide very well defined problems within distinct educational modules (courses), appeared to lead to a general lack of recognition by both staff and students that engineers also had a role as "problem framers", although there were exceptions (5.2.10). This emphasis and pride in pragmatic problem solving as limiting confirmed the view of the Australian review (IEAust, 1996) and several other authors (Lee & Taylor, 1996a; Stonyer, 1998) that the education process appeared to turn out graduates who saw their role as society's problem solvers. These authors argued that this role prevented new graduates from recognising that not only were these problems often defined by non-engineers, but that they, as engineers, might have a unique and valuable perspective on the nature of the "problem". My study has confirmed how deeply embedded this role of "problem solver" is within the "Engineering way of thinking".

Within engineering education there was an unquestioned assumption that the knowledge, the mathematical procedures and scientific processes, and the laws on which problem solutions were based were free of race or gender bias. I found no recognition that the ethnocentricity and masculinity of the sources of engineering knowledge and procedures might affect not only problem definition, but also, accepted methods of problem solution, teaching or assessment. I did find recognition that problem solutions must meet the needs of the community. Culturally appropriate solutions were, however, viewed as just one of the constraints engineering solutions must work within, rather than a recognition that alternative epistemologies might exist.

### 7.2.2 The Relationship of Engineering to the environment

Schein proposed that members of a culture develop shared views of their relationship to their defined and perceived environment within larger host cultures (Schein, 1992, p.131). As I mentioned earlier, engineering education operates within the academic environment of higher education but also with responsibilities and strong linkages to the profession. In this section, I consider the School of Engineering's shared assumptions and beliefs about its relationship with the rest of the university and the engineering profession.

My results indicated a strongly held belief in the School of Engineering's ability and desire to control its own destiny within the wider institution. The School appeared to see itself as having a separate identity from the rest of the university, able to be self sufficient. In Chapters 4 and 5 I spoke of occasions when a "go it alone" mentality prevailed. This may have been a legacy of the former time of physical separation from the main campus, but it also appeared to have its roots in a pride and sense of superiority in its ability to solve problems, whether the problems related to space usage, allocation of funding, timetabling or parking. The symbolism of the term "across the road", spoken of in Chapter 4, epitomised the position of the engineering education culture within that of the main university, on the edge, rather than completely within the university as a whole.

Despite School of Engineering's belief in its self-sufficiency, however, it was the university that conferred the qualifications, received government funding and had regulatory control. Many of the behaviours and practices found in this case study, therefore, reflected the beliefs and assumptions about teaching and learning found within the wider university (see sections 4.2, 5.3). An example of one (see section 5.3.3) was the university requirement for individual assessment, even in group projects.

Shared beliefs and assumptions were also evident in the linkages the School of Engineering had with the engineering profession. A close relationship with the professional and industrial sectors, discussed in section 5.6, was both valued and taken for granted. This relationship was a response to the recognition by staff and students that the prime objective of the undergraduate degree was to educate graduates with the appropriate expert knowledge to operate as professional engineers. It was assumed that the curriculum would be not only monitored, but also shaped, by the needs of the profession (see Appendix 11).

My results have also indicated that the culture of the School was influenced by changing economic and political environments. These changes had the power to affect behaviours and practices, which, if they were sustained, might cause changes at the level of beliefs and assumptions. In Chapter 4 I discussed one such example –

the change in government funding which was perceived to be the impetus for expansion of student numbers as a means of ensuring economic survival for the School. This expansion, over the time of this study, had started to bring changes from an integrated "family" culture to one of potential fragmentation. Another external influence was the change in government immigration policies in the early 1990s resulting in an increased cultural diversity in the composition of student and staff bodies, and the consequent likelihood of diverse personal values.

### 7.2.3 The Engineering identity

Schein (1985, 1991) used the term "Nature of Human nature" to look at what attributes might be considered intrinsic for someone belonging to a particular culture. In my case study there seems to have been a very clear identification with the term "engineer" as implying common attributes and attitudes. Hence, I have named this dimension the Engineering Identity – suggesting that there were beliefs and assumptions around what attributes and qualities were inherent in being "an engineer", and who fitted in and was successful.

In an academic or intellectual sense, the most fundamental attribute for both staff and students appeared to be that they and their peers were all high achievers academically, with above average ability in mathematics and scientific understanding. They sometimes described themselves as "Can Do" people, proactive achievers, who if given the resources would accomplish tasks efficiently and effectively. My data suggested that engineering staff and students had a trust and respect for colleagues, with the expectation that delegation was safe because their colleagues could, and would, deliver what was expected. Students may not have started out this way, but by the time they had completed the degree, trust and expectation seemed to have developed, possibly through their experiences working on projects in groups and teams.

The logical, step-by-step way that many engineers thought and reasoned was demonstrated by a comment "*they think in bullet points*" rather than descriptive, flowing sentences. Using this approach, I have listed the qualities and attributes that appeared from my data to be common throughout engineering education. Engineers might be expected to be:

- Numerate – use numbers confidently and competently to explain situations both everyday and technical;
- Practical – competence and confidence with technology and computers was assumed;
- Tough, self-reliant, and capable, where toughness represented a personal strength of character rather than physical strength;
- Not emotionally demonstrative – trust in logic, analysis and reason;
- Conservative – although the odd "eccentric" was found, conservatism in dress, politics, manners appeared more likely;
- Pragmatic rather than idealististic;
- Humour was valued, often self deprecatory;
- Not overly concerned with style in dress or appearance.

Many of these attributes matched previous studies mentioned in section 2.2.5.3 (Becher, 1989; Beder, 1998; Hansen & Godfrey, 1997; Mclean et al., 1997). I found, however, that some stereotypes were being disrupted by increasing diversity and external influences. For example, while staff and students indicated that to be a "real" engineer had traditionally implied the ability to play hard in ways which invariably involved the copious consumption of alcohol, they recognised that this stereotype was changing and a contemporary engineering stereotype was likely to be of a clever, hard working problem solver.

Engineers were still, however, largely assumed to be male (Beder, 1998). To be female was to be "other" – an accepted and often respected "other", but different nevertheless. It required a conscious effort for most students and staff to use gender inclusive language when speaking of engineers in general. This was an environment in which belonging continued to be associated with being "one of the guys".

The most notable feature of this dimension of the culture was the strength and pride with which both staff and students commonly spoke of themselves as engineers rather than specifying their sub-discipline. A strong sense of pride, bordering on arrogance, appeared linked to this collective identity as engineers. I have provided examples in the previous chapters of how this identity was manifested in language, publications, dress and the relationship to the rest of the university, as well as in the discourse that framed engineering as a "hard" degree.

### 7.2.4 The Engineering way of doing.

Schein named one of his dimensions as "the appropriate way to act". From my findings I have identified shared assumptions around how the following questions were answered in this disciplinary culture: What was the primary task and how was it accomplished? What was perceived as the "right" way to teach and learn? I have named this dimension "The Engineering way of doing".

As I discussed in Chapter 4 the Mission of the School of Engineering was to be the pre-eminent engineering school in New Zealand (4.2), and one of their primary tasks was to educate and graduate students with a professional engineering degree. In other words, Teaching and Learning goals were of primary importance.

In Chapters 5 and 6 I dealt at length with the practices and behaviours of staff and students with respect to teaching and learning, inferring from my evidence that one of the most basic assumptions underpinning the way engineering was taught was the belief that anything worthwhile was hard. I spoke in Chapter 6 of ways in which the theme of "Hardness" seemed to permeate throughout engineering education, conveying worth and status, with a devaluing of content or subject areas which were seen as "easy" or "soft". The heavy workload found in many other studies, referred to in Chapter 2 (for example, IEAust, 1996; Lee & Taylor, 1996a; Seymour & Hewitt, 1997), was evident in this study as part of the apparently taken-for-granted "challenge and stretch" approach to teaching. This teaching paradigm implied pushing or pulling students to new limits. The strength and ability to "take it" and succeed within this paradigm appeared to contribute to the pride and sense of achievement that students spoke of as an outcome of completing the degree. This equating of "learning" with "shared hardship" appeared to be part of the educative process, which developed and strengthened attributes perceived as needed by a professional engineer. Even teaching was enacted as "learned the hard way", by learning on the job rather than by specific professional development (see 5.2.8).

Although I recognised that individual features of the curriculum might be influenced by pragmatism and compromise with resource issues, the curriculum content, teaching and assessment evolved from beliefs and assumptions around the "right" way to teach and learn engineering. The prevalence internationally of a sizeable core of technical content deemed essential in the engineering curriculum (Ford & Ford, 1994; Lewis et al., 1998 as cited in Chapter 2) was supported by my findings. While the compulsory content, with its lack of flexibility, may have existed in response to the requirements of professional accreditation, it was deeply entrenched in the beliefs of the academic staff. The latter found it very difficult to consider reducing or leaving out sections of material. Much of this "essential content" was taught through traditional, lecture based courses and was seen as the fundamental knowledge that distinguished engineers as experts in their field.

My findings, discussed in Chapters 5 and 6, exposed Design courses and project-based learning as core activities of engineering education at this institution. These aspects of the culture have not been highlighted in previous cultural studies of engineering education, except in the work of Tonso (1996b, 1997) who recognised the important role of these courses in how students "learn what it means to be an engineer" (1996b, p.218). Staff at the U of A believed that these courses modelled the activities that would be required of students in their working lives as professional engineers, with problem solving their major task. The focus on problem solving appeared to have led to a belief, firstly, that for every problem a solution existed (possibly only a "best" solution, rather than a perfect one, but a solution nevertheless), and secondly, that with the appropriate expert knowledge and "toolbag" of skills and procedures, they, as engineers, could solve any problem.

The long history of incorporating professional development and communication skills, including management and social and environmental responsibility, into the curriculum, was another unique feature of the case study institution. From the recommendations of the Australian review (IEAust, 1996) I inferred that the majority of engineering institutions did not, at that time, include this material in their curricula. My data suggested that most Engineering staff at the U of A held a shared belief in the need for these courses as part of the students' preparation for the profession. There appeared to be, however, a tendency for the material to be marginalised in these courses and spoken of, by both staff and students, as “soft” compared to the more technical “hard” courses.

Within this culture of the case study institution, both competition and co-operation were perceived to be important as appropriate forms of behaviour (see 6.2.2). The aims of individual academic excellence and achievement of a qualification were widely seen to be integral to the nature of a university, with the result that I saw competition for grades as a basic assumption about the nature of human activity. I found ruthless competition to be the exception rather than the norm, and I found that both co-operation and collaboration were valued highly. My evidence, discussed in Chapter 6 suggested that these characteristics were not only encouraged and valued by staff as preparation for a professional working style (see Appendix 11), but seen by students as essential for optimal learning and academic survival.

As I discussed earlier, external factors in the last decade appeared to have resulted in some values and cultural norms, such as an instrumental attitude to learning, becoming part of the essence of the culture even though they did not match espoused values and goals. These external factors included large increases in tuition fees and student loans, increased diversity in prevalent learning styles and the pressures of growth in student numbers, not matched by growth in resources. The processes of education appeared to be increasingly seen by students as the pathway to a qualification, a piece of paper, rather than to a profession. The assumption, seemingly shared by a large proportion of students, that the goal of their learning was to pass rather than to understand, was manifested in the “go for grades” attitude and desire for “spoonfeeding” commented on by staff (reported in Chapters 5 and 6). This attitude was in direct contradiction to the beliefs and assumptions staff held about the goals of their teaching being for understanding as well as knowledge

### 7.2.5 Time

I saw the use of time, and how time was defined, as an important dimension of the engineering education culture, not commented on by previous cultural studies. Time in this culture appeared to be inelastic, a constraint to be managed as other resources were managed. Weaving through my results were themes of working to deadlines, planning timelines for projects, and rationing out time between assignments, part time work, pleasure and socialising. The workload might vary, but time was seen as limited. Prioritising a heavy workload within stringent time constraints was a major feature of the educative process and learning environment. When students and staff spoke of the "best" solution they rarely meant perfection, but rather the "best" that could be accomplished within a specific time frame. This attitude, that time was precious and not to be wasted, was manifested in comments like "*if you can't sum it up in an executive summary on one page it won't get read*" and "*you've really got to manage your time*". Working to deadlines led to a "just in time" culture where tasks were completed, but rarely ahead of time, and often being worked on right to the last minute.

The development of these assumptions and beliefs about time may have been exacerbated by the constant exposure to a heavy workload. Alternatively, it may have stemmed from a profession in which the development of a product or project was governed by deadlines at all stages from tendering to commissioning.

For academic staff, the working day was not defined contractually, implying an assumption of autonomy in the usage of time. Despite this autonomy, within the School there appeared to be a self-regulated tradition of keeping regular hours that was not perceived by staff as the norm elsewhere on campus:

> *Norm is to work in here every day – I suspect it is noted by various people if your room light is not on, people make sure they leave their door a little open when they are in …very much a part of our culture* *SStaff3, September 00*

### 7.2.6 Relationships – Mates and the sense of belonging

The nature of relationships, the "right" way for people to relate to one another in a culture is an essential dimension in a cultural study. The unconsciously held beliefs and assumptions about appropriate levels of intimacy, and formality in a particular setting, determine responses and behaviours for members in the culture in both familiar and unfamiliar situations.

With respect to relationships, two quite consciously held beliefs ran throughout both staff and student experience in this study. The first was the assumption that the

School operated and would continue to operate in an integrated way, with strong interdepartmental cooperation a “given”. As I discussed in Chapters 4 and 5 (particularly sections 4.2, 4.4.1, 4.4.3, 4.4.4, 5.2.8, 5.5.2) this assumption was explicitly identified in strategic plans and conversation as well as manifested in administrative, financial, curriculum and social interactions.

The integrated nature of the culture was also exemplified by the strong “family-like” relationships verbalised and enacted by both staff and students (see 6.3.3). As I commented earlier, the opportunity afforded by prolonged close proximity, particularly in class groups, enabled close relationships of varying degrees of intimacy to develop. Signs of potential fragmentation were, however, apparent at the time of my study as a result of the growth of student numbers, and increasing ethnic diversity.

The second belief about relationships, which I identified from the student data described in Chapter 6, was the importance of “mates” and the linking of friendship relationships to a sense of belonging. A personal desire for friendship could be expected in any group, but what was particular to this culture was the dominance of the perception that academic/ task oriented friendships were essential to success in this learning environment – an environment that consumed the students’ time and energy and consequently had the potential to isolate them from other friendship groups. The comments I included in sections 6.2.2 and 6.3.3.2 demonstrate the shared view that academic survival and success would be very difficult for any student who was marginalised or a “loner”.

Other authors have written about a sense of “fit” (Lewis et al, 1998) and relationships (Seymour & Hewitt, 1997). However, in my study, the strength of the perceived need for these relationships emphasised the importance of what happened outside the classroom in the educative process, particularly an educative process characterised by the “challenge and stretch” paradigm or “hardness” I identified in section 7.2.4. The need to belong and have mates had the potential for students who might be viewed as different, by reason of age, ethnicity, educational background or gender, to be at risk in this environment. Evidence I presented in section 6.2.2 suggested that students who did not find a niche or supportive group (however large or small) were discomfited on a personal level and rarely reached their full academic potential.

Staff-student relationships appeared to be characterised by a sense of care, which I saw as contributing to the sense of “family” mentioned earlier. My data implied that staff-staff relationships were predominantly task-oriented or work based. Staff spoke with warmth and respect of their colleagues, but few spent time with each other or their families outside of work hours.

Power differentiation in relationships was seen by staff as low, relative to other faculties and overseas institutions. This was illustrated by an informal, egalitarian atmosphere where first names were acceptable forms of address even between staff and students (particularly senior students). Joking and teasing were common features of relationships, usually implying acceptance as a member of the group. Conflict appeared to be avoided rather than confronted, with the greater majority of interactions taking place in an atmosphere of courtesy and respect. Division and heated debate, if they occurred, were conducted in private, with issues usually resolved prior to any public forum.

### 7.2.7 Homogeneity vs diversity

In my earlier definition of culture, one of the essential features was the existence of shared assumptions. Consequently, issues of homogeneity and diversity and the implicit potential for shared or diverse values and norms provide another dimension to be studied as part of a cultural analysis. Questions such as: Is homogeneity desirable or necessary?; and How is difference accepted? have not been addressed in previous studies of the culture of engineering education. Arguably, diverse educational or ethnic backgrounds are likely to result in newcomers bringing diverse personal values and beliefs. In return, these would be likely to affect the speed and degree to which individuals adapt and adopt the values and norms, and ultimately beliefs and assumptions of the disciplinary culture at a particular institution.

As stated earlier, for ethical and privacy reasons I have been selective in this study in presenting data relating to staff. I have spoken in section 4.7.1 of the composition of the staff and student bodies. I identified a core of long serving male staff who provided a storehouse of cultural memory of “the way we do things round here”, with a higher degree of homogeneity in educational values and background than might be encountered in other institutions. This appeared to be a strong contributor to the integrated nature of the faculty. New staff with engineering qualifications, particularly from Australia, Great Britain or the United States, were assumed to share common academic values and attitudes. This assumption appeared to be based on the recognition that engineering education had many similarities internationally, and other than local differences in curriculum or emphasis, the beliefs and assumptions referred to in earlier sections in this chapter were likely to be culturally transferable. I argue that an intensive study of staff beliefs and attitudes would reveal that diversity in educational beliefs and attitudes was likely to occur with new staff whose qualifications were not in engineering, but from other disciplines such as applied mathematics, materials science or environmental science.

My own observations combined with the perceptions of staff interviewed indicated that difference at a personal level such as race, gender or prior experience was tolerated and accepted provided attributes matching those described in 7.2.1 and 7.2.3 were evident. Common interests, such as an enthusiastic interest in jogging or golf, often provided initial acceptance, but it was evidence of competence and high achievement in both teaching and research, coupled with reasonable communication skills that earned long term respect and inclusion. The majority of female academic staff in the School at the time of my study did not have a traditional engineering academic background. Over a number of years I observed that acceptance and respect for them appeared sometimes to be a slow and painful process. These women often brought with them ways of thinking, doing and being which were outside the engineering norms described earlier. This accentuated their “difference”. Although I am not able within the defined limitations of this study to provide supporting evidence at this time, my observations and discussions with these staff over a number of years supported the hypothesis that their acceptance, manifested in ways such as promotion and inclusion in decision making, depended on their ability to adapt to the prevailing culture, rather than the prevailing culture adapting to absorb their difference.

When speaking of homogeneity and students, it is necessary for me to separate homogeneity in an academic sense from the social. The selection procedures made possible assumptions about homogeneity of academic background. High achieving school leavers made up a very high proportion of new entrants, with considerably fewer numbers of "mature" age entrants. In 7.2.6 I spoke of shared beliefs in the importance and need for supportive relationships amongst students. In the first instance, the formation of supportive friendships was likely to be assisted by students who could easily find friends with the same interests and background. In reflecting on how "difference" was handled, I found that the acceptance and inclusion of students regardless of race, gender or age appeared to depend more on fitting in with an engineering "norm". One norm was to be male, but for female students their gender appeared to be less marginalising than ethnicity and background experience. There was evidence, for example, that male students were initially more accepting of female students of the same ethnicity than they were of males of different ethnicity. Students with reasonably outgoing personalities and the attributes described in 7.2.3 appeared to be accepted and successful within the culture regardless of race, background, gender or age. Four years of close contact provided many opportunities to cut across any social divisions. In the later years of the degree especially, relationships and interaction demonstrated that difference was accepted, and homogeneity in personal backgrounds was not essential for academic or personal success.

### 7.2.8 Summary

In this section I have brought together from the material of the previous three chapters, as the third level of my analysis, the "taken for granted" beliefs and assumptions which I viewed as the essence or core of the culture of engineering education. I have grouped these assumptions within seven dimensions:

- The Engineering way of thinking
- The Relationship of Engineering to the environment
- The Engineering identity
- The Engineering way of doing
- Time
- Relationships – Mates and the sense of belonging
- Homogeneity vs diversity

My analysis reinforces and confirms features of engineering education which can be recognised, not only in my case study institution, but in some cases also in the international literature of engineering education as cited in Chapter 2.

My particular contribution has been to put a spotlight on assumptions, such as those around the integral role of mathematics and design in engineering education, and provide a mechanism to re-examine that role. If, as critics have implied (Beder, 1998), mathematics is over emphasised in the curriculum, deconstructing this emphasis by examining practices and behaviours, as I have done in Chapters 5 and 6 (particularly sections 5.2.5 and 6.4.1), has the potential to provide insight into how (or if) change might be implemented. Unless basic assumptions are articulated and confronted, they will not be subject to re-examination and reflection, and criticisms will be met with a lack of comprehension.

Bringing together these seven cultural dimensions, has also provided a balanced view of the culture which highlights not only the social aspects of the culture, but the academic, recognising that "what goes on" both inside and outside the classrooms contributes to the formation and maintenance of the disciplinary culture.

## 7.3 Interaction with gender

Section 7.2 has provided my answer to the first part of my first research question – to identify the dimensions of the culture of engineering education in the case study institution. Before examining the second part of that question, namely, how those dimensions interact with gender, it is appropriate for me to briefly restate my thinking on the use of gender in this study. In Chapter 2 I followed the lead of gender researchers (Connell, 1995; Gilbert, 1996; West & Zimmerman, 1991) by viewing "masculine" and "feminine" as constructs we use to make sense of the world, constantly being negotiated within a culture rather than invariant characteristics.

In Chapter 2, I noted that one way that gender had been linked to culture was by the concept that cultural beliefs and assumptions were likely to be associated with common perceptions of one gender implying that a culture itself could be considered gendered (Baker & Fogarty, 1993; Parker et al., 1997). In this section I will consider the implications, with respect to gender, of the beliefs and assumptions of the cultural dimensions that I have identified in 7.2, linking my findings to literature reviewed in Chapter 2.

I will discuss the construction of gendered identities within a culture, in Chapter 9.

### 7.3.1 The Engineering (gendered?) way of thinking

In section 7.2.1 I identified the Engineering way of thinking, and valuing knowledge using terms such as

- logical,
- quantifiable,
- provable,
- pragmatic,
- linked to "real life", and
- dominated by problem solving.

This reflects definitions such as that of Forisha (1981, cited in Alvesson & Billing, 1992) which have commonly identified masculinity as linked to qualities such as "rational, analytical, problem solving".

Gender theorists quoted in Chapter 2 (e.g. Belenky et al., 1986) had suggested that more men than women operated as "separate knowers", where separate knowing was linked to traditional, objective, rule-seeking ways of evaluating, proving and disproving truth, suggested as prevalent in physics and engineering. The engineering way of thinking, which I have identified in 7.2.1 appeared to me to be dominated by "separate" knowing, which might therefore be seen as advantaging men.

Belenky et al.'s concept of "connected knowing" has been described (Roberts & Lewis; 1996, Rosser, 1995) as knowledge and procedures taught in the context of real life applications. One of the teaching goals at my case study institution was to link knowledge with real life applications implying that "connected" knowing was valued. Although I reported in Chapter 5 that female students strongly affirmed this approach, appearing to support Belenky et al.'s suggestion that this way of knowing was more common amongst women than men, I found that male students also appreciated “connection”. My findings appeared to support the work of Baxter Magolda (1992) who repeatedly emphasised that patterns in ways of knowing that revolve around connection were related to, but not dictated by, gender and were used by both men and women. I would also argue that there was an inherent risk in assuming that the inclusion of real life applications would result in a gender neutral or even gender inclusive teaching style. This begs the question of “Whose real life did the term real life applications refer to?”

Several authors have recognised that female students and male students bring different life experiences to their engineering education (McIlwee & Robinson, 1992; Roberts & Lewis, 1996). My findings verified that the majority of female students in this study perceived male students as having greater connections with the knowledge and procedures of engineering. These perceptions were also supported by the Australian review (IEAust, 1996, p.15) which stated that “engineering education has been largely based on traditional male knowledge, interests and skills”, explicitly acknowledging the masculine sources of engineering.

In 7.2.1 I identified the valuing of the definable and measurable as integral to the engineering way of thinking and the implied valuing of “hard facts” rather than opinion or indecision. Lloyd (1993) proposed that, since Pythagorean times, certainty and precision have been associated with maleness, and seen as good, whereas indecision has been seen as bad and associated with femaleness. In Chapter 2 I discussed how masculinity and status had been viewed (Schiebinger, 1999) as linked to the left side of dichotomies such as: hard/soft, definable/indefinable, logical/intuitive. The terms hard, soft, pure and applied have been related to a hierarchy of disciplines (Becher, 1989; Neumann, 2001; Thomas, 1990) and Thomas linked this hierarchy to a gendering of disciplines. In such a hierarchy, engineering was categorised as hard and applied and very strongly linked to masculinity.

The emphasis on problem solving within engineering carried with it implications of an outcome oriented culture. Engineering education necessarily emphasised the teaching and assessment of the processes of problem solving, which could be seen as masking this outcome focus; however, the goal for students was always to find a solution. The process of achieving an outcome in the design projects and competitions described in the previous chapters was of little consequence. The priority and focus was on a successful outcome, one that “worked” and fulfilled its design brief. Outcome or results oriented cultures have been linked to masculinity (Cartwright & Gale, 1995).

In 7.2.1 I identified that engineering was often concerned with “best” or “optimal” solutions within specified constraints or problem definition. The subjectivity inherent in problem definition, as well as in the judgements and assumptions made in choosing the “best” solution, appeared to me to be masked by the mathematically provable steps and technological facts of problem solution, which implied logic, rationality and particularly objectivity. Within the constraints of the pre-defined, bounded problems presented at the educational level, I found little evidence that female students or staff provided different options and solution to those of their male peers. This, for me, suggested an enculturation into the engineering way of thinking that neutralised potentially gendered subjectivities in problem solution. At the level of problem-framing, I found female students and staff often demonstrated a desire for relevance and “connection” in their choices of project and research topics. This confirmed that Alvesson and Billing’s (1992) suggestion that women, compared to men, were more likely to be directed to the resolution of “real life” problems than towards abstract or hypothetical dilemmas.

In this section I have shown that the engineering way of thinking and valuing knowledge identified in 7.2.1 was strongly linked to ways of knowing named by a range of sources in the literature as masculine. There were, however, aspects of that way of thinking which could also be said to link to feminine ways of knowing. The applied, contextual nature of much of the knowledge and learning in engineering education appeared likely to appeal for those students and staff, both female and male, who might see themselves as “connected” knowers and could account, for example, for the higher participation of females in engineering than the more theoretical subject of physics in my case study institution.

### 7.3.2 The Relationship of Engineering to the (gendered?) environment

As I discussed in Chapter 2, and in 7.2.2, engineering education is a discipline situated within the culture of higher education yet influenced to a very large degree in curriculum, content, social and cognitive style by the profession for which its graduates were intended.

The profession of engineering has been described in Australia as the most sex differentiated of all the professions[2]. Further, despite rising female participation in engineering education, current statistics (quoted in Appendices 1 and 2) show that, for Australia and New Zealand, women's participation in the profession is still at the exceptional or "token" level. An examination of the governing boards of both IEAust and IPENZ reinforces the view that, in these two countries, cultural values and attitudes within the engineering profession were formed and continue to be sustained by the dominant white (Caucasian) male participants. Researchers such as McIlwee and Robinson (1992) have identified in an American context that the professional engineering culture was "interactionally presented in a form closely tied to the male gender role" (p.19), and despite some national differences in how that role is enacted, my data suggested that their statement applies in the context of my research.

Internationally the culture of higher education has also been widely regarded as gendered (Baker & Fogarty, 1993), with both values and patterns of socialisation (Parker et al., 1997) based on masculine models, and leadership almost entirely composed of white males. Although I argue that both the academic and professional engineering cultures can be labelled as gendered, the work of Connell (1995) on the existence of different masculinities leads me to suggest that the masculinities generally evident within academia appear to be reasonably compatible with the resources and attributes of women students and staff (if the greater than 50% participation by women in higher education can be used as a guide).

The culture of engineering education at my case study institution was also influenced by the values, beliefs and assumptions of the local and national culture. The latter, it

[2] Legislative Council extract – Industrial Relations Bill – Tuesday 15 October, 1991 . Available from www.parliament.nsw.gov.au

has been suggested, could be considered as a "gender culture" in which distinctly male and female cultures exist, with all social relations structured and understood through concepts of masculinity and femininity (James & Saville-Smith, 1989) and the national identity linked to that of the male (Phillips, 1996). New Zealand has, however, a proud record of female achievement in the political, sporting and academic arenas, which might suggest a culture of gender equality or at least one where femininity does not preclude strength and ability.

### 7.3.3 The (gendered?) Engineering identity

In section 7.2.3 I discussed my findings about the beliefs and assumptions around what it meant to be an engineer, and what could be assumed about the nature of fellow colleagues or students. The qualities I identified as the norm for an engineer included numerate, practical, tough, self reliant, unemotional, conservative and pragmatic – all attributes traditionally associated with masculinity (see Forisha (1981) cited in Alvesson & Billing, 1992, p. 75).

Phillips (1996) had described the characteristics of the typical New Zealand male, using terms such as; a rugged practical bloke, fixes anything, strong and tough, keeps his emotions to himself, usually scornful of women, valuing teamwork, self discipline, modesty, adaptability and quiet loyalty. The similarity of the characteristics described by Forisha and Phillips to those which were commonly attributed to an engineer, illustrated the strength of the assumption that to be an engineer was either to be male or to exhibit attributes and behaviours compatible with masculine models. As reported earlier (Beder, 1998; IEAust, 1996; McIlwee & Robinson, 1992) it was commonly assumed that to be an engineer was to be male. My findings, as presented in Chapter 6, emphasised that even when participation had risen to 20%, it may not have been necessary to "walk, talk and look like a male" (McIlwee, 1992, p. 21) but acceptance as "one of the guys" was desirable for a successful transition through an engineering education.

Academic attributes were not viewed within engineering as gendered. There was an acceptance that female students were likely to be as good academically, if not better, than their male peers with overall female pass rates consistently, albeit not statistically significantly, higher than their male peers. With the exception of two courses at first year level (see Appendix 12), the grade distributions for engineering courses evidenced no statistically significant gender differences in grade distributions. The lack of gender differences in academic outcomes was unsurprising considering that this self-selected pool of female students, entered with school results equivalent to their male peers (see Appendix 12).

There was an increasing awareness amongst staff of the growing likelihood that students, both male and female, had not had exposure or experience in the practical skills that had been traditionally assumed to be the norm for incoming engineering students. Practicality and a "fix it" problem-solving attitude were part of Phillips' (1996) New Zealand model of masculinity, and the typical (male) engineering students of twenty years ago often came from a rural background. Design and project based courses indirectly utilised expertise and experience which lay outside the curriculum, described by some authors as "tinkering experience" (McIlwee & Robinson, 1992). The comments and observations which I discussed in Chapter 6 illustrated the perception of both female and male students that female students did not have strengths in design and the practical side of engineering. This perception was reinforced by the high visibility of male students who excelled as the "heroes" in design competitions, which were viewed as doing "real engineering", the essence of the program. Similarly, despite results which did not indicate gender differences in academic achievement in computer related subjects, the top achievers in software or computer systems projects were almost always male, which appeared to reflect their interest and commitment of time as well as ability.

### 7.3.4 The Engineering (gendered?) way of doing

The theme of "hardness" that I have identified as being linked to engineering education conjured up strongly masculine images. In Chapter 6 I discussed the pervasiveness of this imagery in the discourse, and behaviours, often expressing nuances in meaning of the word "hard" but always with the implied polarisation from the "soft". As I mentioned in Chapter 2 (Becher, 1989; Becher & Trowler, 2001; Thomas, 1990) academic status and masculinity have been invariably linked in research and practice to the "hard" disciplines such as physics and engineering and a lack of status and femininity linked to the "soft" disciplines (Stonyer, 1996). A high proportion of new graduates in my study were proud of the growth that their learning experience had encouraged, but for others the "challenge and stretch" paradigm (see 7.2.4) was a potentially damaging learning style which had resulted in a lack of self confidence and doubts about ability. Other researchers (e.g. Hacker, 1990; Lee & Taylor, 1996a; O'Neal, 1994) have identified the inappropriateness for women (and many men) of an education which equates "ordeals" with learning. As I discussed in section 6.2.3.3 it seemed likely that male students, from their prior socialisation and experiences in sport, education and family life, would be more familiar with this approach.

I observed clear differences in the sexes in the ways they handled the workload and pressure, with female students more likely to verbalise and enact their feelings with helpful friends and support staff. I inferred from my findings that female students were potentially more disadvantaged than their male peers by this teaching paradigm unless the goal of "challenging and stretching" was well explained and appropriate support and training were available. Retention statistics which indicated a higher retention for female students than their male peers could be seen to imply, either that the challenge and stretch paradigm did not disadvantage female students, or that those females who studied engineering had made a well-thought-out choice of degree and were therefore highly committed to finishing. Comments from a significant number of female students indicated that the latter was probably the case – to "drop out" would have been to admit failure.

I found no evidence that the inflexibility of the curriculum, in itself, was a deterrent to female participation in engineering. Other professional curricula such as medicine and law, with much higher female participation, also had prescriptive curricula. Equal proportions of female and male students chose conjoint (double) degrees, although the Arts combination with Engineering, rather than the Commerce combination, was favoured by female students (50% of BA/BE students were female compared to 19% in the BCom/BE). Students of both sexes indicated during interview that they would have liked the opportunity to study courses outside of engineering.

Competitive cultures have been identified as masculine (Traweek, 1984), and those that were more co-operative have been linked with feminine preference (Cronin et al., 1999; Rosser, 1995). In this environment all high achieving, able students displayed a level of competitiveness. Female students were consistently represented in the Honours and Prize lists at levels at least commensurate with their participation levels. As I have indicated in Chapter 6, alongside the competitive striving for grades, a very high level of co-operation and teamwork was both encouraged and seen as necessary for academic survival. I did not, therefore, see the concepts of competition/co-operation as polar opposites in this culture, or as gender differentiated amongst the members of the culture. Rather, they appeared to be linked in a dynamic relationship enabling students to inhabit both competitive and co-operative positions as, and when, appropriate.

Assessment and evaluation appeared to reward and expect a high commitment of time, in relation to work, for both students and staff. Promotion and reward systems for staff catered well for highly focused, heavily time committed behaviours and practices which appeared to have been designed, as one staff member described it, "*for blokes who went home to a wife or mother and a cooked meal*". These systems did not fit well with the preferred lifestyles of female academics who, in the majority of instances, had "other lives" as wives and mothers. Increasing numbers of younger male staff also had family responsibilities, which indicated a potential shift in assumptions about the balance between work and family life. I observed that it was older/senior male academics who had commented that they believed that male students had more commitment to their project work than their female counterparts.

The wide variety of assessment methods used, including the focus on both written and oral communication skills, appeared to remove gender bias in assessment except in a two cases at first year level (see Appendix 12). Even where female students were perceived as disadvantaged by a lack in prior experience, such as Design classes, no gender differentiation in overall achievement was evident. It appeared to me that using gender as a variable in the analysis of assessment statistics was confounded by other variables such as the high numbers of students with English as a second language.

### 7.3.5 Relationships – Mates and belonging

One of the most obvious assumptions about relationships in this culture was the very strong likelihood that they would be male-male. Male socialisation and language styles, the undercurrent of “male bonding” in the joking and teasing, and masculine norms in body language, as discussed in sections 6.3 and 6.4 were taken-for-granted by the male staff and students. The women, both staff and students, were usually very comfortable and accepting of the “masculine” style of relationships but, as illustrated by examples discussed in sections 4.4.3 and 6.4.4, they were often jolted into an awareness of being “other” than the norm. I referred in Chapter 2 (see section 2.6.3.6) to research which demonstrated the power of humour and language, to reinforce, on a day-to-day basis, who belonged and who did not (Hacker, 1981; McLean et al., 1997; Tonso, 1997).

My data provided many instances of the effect of close proximity, class groupings and working in project groups on the formation of accepting, comfortable student relationships, often described as “family”. Female students enjoyed the opportunity of studying and socialising in mixed sex groupings without sexual complications. Some male students mixed in all male groups but it was rare for female students to mix solely with other female students. I discussed in section 7.2.4 the belief that task oriented supportive relationships were an academic necessity and, for female students in a numerically male-dominated environment, some supportive social relationships also appeared necessary.

In 6.3.3.2 I noted the awareness of ever-present boundaries within male/female interactions, and their possible effect on short term and sometimes long term academic progress. This awareness was significant because of the vulnerability and visibility of the minority group (females) in a numerically male dominated environment where single sex (male-male) interactions in the academic setting were much more familiar to the majority of the group.

Staff student relationships, discussed in 6.3.2 were considered to be friendly and often informal, but I found evidence that both parties found male-male or female-female interaction less restrictive. The perception that female students received help more readily from academic staff (predominantly male) than their male peers (commented on in section 6.3.2), appeared to imply that all were aware of the undercurrents of gendered behaviours.

It seemed evident to me that the traditional norms of male-male relationships within engineering education were likely to provide a more comfortable and easy social integration for male students. For female students, relationships had the potential to be complicated by gendered behaviours and expectations which were not an issue for their male peers.

### 7.3.6 Summary – a gendered culture

In section 7.3 I have demonstrated, using my study as evidence, supported by a wide range of research literature, that the culture of engineering education in my case study institution was founded on, and sustained, by values, beliefs and assumptions, which have been linked to masculinity. Arguably then, the culture is therefore a gendered, i.e. masculine, culture. I am not suggesting that these values, beliefs and assumptions are shared by all male persons or only by males, but that they have been commonly linked to understandings and expectations of what it means to be male.

## 7.4 Learning the Culture – Research Question 2

The second of my research questions was:

- How is the culture of engineering education learned in the case study institution and how does gender interact with this learning process? .

The seven dimensions of the culture of engineering education that I have identified in section 7.2 incorporated the shared beliefs and assumptions, which appeared to be held at an almost unconscious level by members of the group. As I have discussed in Chapter 2, inherent in the concept of a culture is the understanding that new members entering the culture undergo a learning process, an enculturation into a well-established system of practices, behaviours, values and norms. This process of enculturation into the “disciplinary regime” has been referred to by other authors at both academic (Lee & Taylor, 1996a; Snyder, 1971) and at social levels (Tonso, 1996b) but the dynamics and processes by which the cultural elements are transmitted and passed on to new students have not been previously documented. My study has filled this gap by providing detailed evidence of these processes, in the previous three chapters, which are synthesised in this section.

My data included observations and end of year interviews with first year students, whose enculturation I found surprisingly well advanced, as well as observations, survey and interview data with final year, graduating students. Most notable by final year was the level of commonality in attitudes and beliefs. In surveys and interviews, themes were consistently repeated, cutting across gender and ethnic differences.

When first year students enter the university, they are not coming as empty vessels waiting to absorb new knowledge, values, beliefs and attitudes. They already inhabited the “multiple worlds” (Phelan et al, 1991) of family, peer groups, school, and church communities, with an understanding of the cultural knowledge, values and attitudes required to move between those settings. From the first day at orientation, I watched them as they moved into another “world”, that of the university and in particular the School of Engineering, a community that I have shown to have its own distinctive knowledge, language, criteria of validity and reliability, traditions and values. Their comments, particularly those in Chapter 5 and 6, illustrated how efficiently they were reading the cues and adapting to their new educational experience.

I saw the need to adapt as critical to the students’ success both academically and personally. My observations confirmed that adaptation was easier for those students whose experiences and personal value systems were similar to those in the new culture, and I found Byrne’s (1993) analogy of adaptation to an institutional ecology particularly apt. I have identified earlier in this chapter that the dominant culture was that of the NZ-European male. Throughout their engineering education, predominantly male lecturers and tutors “role modelled” not only masculine behaviours (including humour, body language, and language style) but also a cognitive style that, I have argued in 7.3.1, was itself masculine. I observed very little time lag in adaptation for male European students, for whom the engineering education environment offered little conflict with their existing identities. Female NZ-European and NZ-raised students of non-European ethnicity, familiar with these behaviours and learning styles from their previous experience of learning mathematics and physics in high school were also quick to adapt. For students coming from very different educational and cultural systems however, it was often several months, or even longer, before they appeared confident on a personal level, built friendship groups, and adapted academically.

I have presented evidence in earlier chapters that the dominance of the hard drinking, boozy image of a "real" engineering student, did not match reality for the majority of the students. Comments like "*come and be blokes and mates - I don't think many of the first years can take to that*" (Brian, 1st year student 1998) illustrated that students were selective in choosing aspects of the culture with which to identify.

The strong urge to "fit in and belong" started at Orientation, and the comment "*Everyone just wanted to belong somewhere in engineering and it was easy because everyone was looking for friends" (*Sue, 1st year 1998) was typical for the majority of the first year students I interviewed.

I recognised that the transition process was likely to be similar for all students entering higher education but for the first year engineering students in my study there were several unique features.  Firstly, they were not only entering higher education but specifically engineering education and potentially the profession of engineering. From the first day at orientation (see 5.5.1) and throughout their four years of study, they were reminded that they were not just attending university to gain an education, but to learn what it meant to be an engineer – the knowledge, skills and attributes they would need in the profession. Secondly, their identities as engineers had to be constructed alongside their growth as individuals, in particular as women and men operating in a culture that I have identified as masculine.

In Figure 7.1 I have represented diagrammatically the processes of learning the culture.

Students learned the culture i.e the shared values, beliefs and attitudes, initially by seeing, hearing and interpreting the various day to day practices, behaviours and events that took place around them ( the first level). This learning process started with Orientation, discussed in detail in section 5.5.1, which made explicit the espoused values and norms as seen by the presenters, who included members of the profession, staff and current students.  Over the next few months, the students' urge to succeed both academically and socially in the university environment heightened their perceptions, and they quickly picked up on appropriate strategies and behaviours. (One student compared the quiet watchful behaviour in the first week's lectures to noisy, chatty behaviour evident only weeks later!).

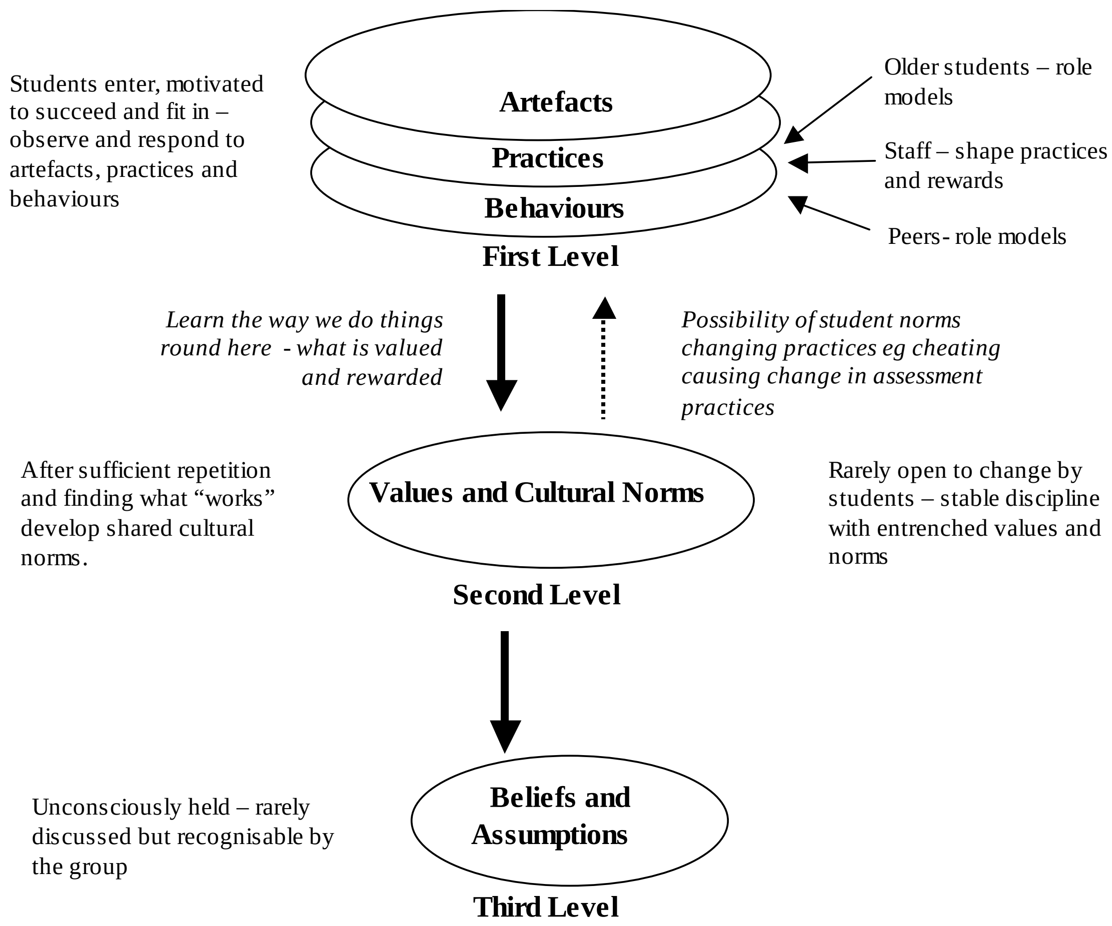


Figure 7.1 Diagrammatic representation of the processes of enculturation

The observable and tangible manifestations of the culture that I have discussed under the headings of Artefacts, Practices and Behaviours were influenced and modelled primarily by staff, who were the major transmitters of the academic side of the culture. As noted in Chapter 5, staff tend to teach the way they were taught, transmitting style and content together, even if in their own practice they have found other styles more appropriate. I have discussed their influence at length, particularly in Chapter 5 in the sections on Pedagogy and Assessment and in Chapter 6 in the sections on Relationships and Behaviours in the academic learning environment. Senior students also had a role to play in transmitting cultural values and norms and I have discussed their role in detail in sections dealing with Events, (5.5) and Publications (4.3.2). If left to senior students, however, it is doubtful whether the culture would be as stable as it appeared to be. The transient nature of student cohorts (with annual intakes and only four to five year stays) limited their ability to learn and then transmit cultural values and norms. The staff, most of whom had themselves been through an engineering degree were more of a stable group, and appeared to hold shared understandings of the "engineering way of thinking and doing". They had the power to set curricula and pedagogy, affirm culturally appropriate behaviours, and reward (using assessment) ways of thinking and reporting. The students' peer group also contributed to the process of enculturation, by affirming appropriate behaviours and practices by way of task-oriented friendships and support strategies.

As students moved through the degree program, the process of repeatedly finding out what "worked" and was rewarded led them to learn and identify with the values and cultural norms which they perceived as congruent with the identity "engineer"(the second level). These values and norms were well entrenched in this very stable academic discipline and I saw them as rarely open to change by students.

I shall discuss in Chapter 9 how cultural change might occur, emphasising that it is more likely to come from those with power to put in place practices and artefacts which would reinforce behavioural norms matched to desired values. I saw instances, however, where cultural change had come from the students, as when strong student values and norms persisted which did not match those espoused by the staff, leading to changes in both teaching and learning practices and behaviours. One example was the response to the cultural norm for high on-course assessment and the "challenge and stretch" pedagogy. When this workload was perceived as excessive by the students, it appeared that the valuing of individual integrity became a lesser priority for many students than gaining a successful academic result and cheating practices became a cultural norm. This in turn resulted in a shift in assessment methods from those of the ideologically preferred project based learning to supervised, timed tests.

The third stage in learning the culture would be the extension of shared values and norms to an understanding of the basic beliefs and assumptions which underpinned them (the third level). Schein's theory (1985) had suggested that participants in a culture were rarely aware of this level of culture, that these core beliefs and assumptions were unconsciously held and rarely discussed. In contrast, these student comments, brought together from my findings in Chapters 4, 5 and 6, confirmed for me that engineering students, even in their first year, had gained some appreciation and ability to recognise an "engineering way of thinking" or "way of doing" and what it meant to be an engineer:

> *Like to think like an engineer, kind of being taught it I suppose. John, 1st year 1998*
>
> *I think that thinking as an engineer is thinking of the theoretical best solutions to problems and then the best practical way of doing it* *Joshua, 1st year 1998*
>
> *As far as a "way of doing things" goes, a facetious response would be "so they get done", or possibly "using maths" …* *Laurie 1st year 1998*
>
> *Engineering can be very narrow, very focussed on one point, solve the problem goal oriented… I would put it down to our training, the way we are taught to think and act.*
> *Samuel, new graduate Civil, 1997*
>
> *I found it hard until I got into the engineering way of thinking …the way of analysing a problem and working out how to go about solving it …you are not really taught it …you sort of pick it up* *Sally, 4th year C&M 1997*

The common Part I program, taught "in-house" rather than by science faculty, was an explicit manifestation of the desire to start enculturating students right from the beginning (5.2.1) and introduce them into the "engineering way of thinking" (5.2.3).

Previous cultural studies have not included analyses of the role assessment played in enculturation. In Sections 5.2 and 5.3 I have therefore described in detail the practices of teaching and assessment, from which students, starting in their first year, learned the cultural norms and values of engineering education. Assessment, in particular, appeared to play a vital and effective role in reinforcing these cultural norms and values, the effectiveness of which was demonstrated by the shared understandings of the comments above. The integral role of mathematics and problem solving in engineering education, was established early by the examples such as those I provided from the first year courses. In section 5.3 the assessment examples I presented, starting from the first year courses, manifested the basic cultural assumptions of: understanding demonstrated by the application of mathematics; the importance of communication skills; and the role of the professional engineer in areas of social and environmental responsibility.

## 7.5 Summary – An Integrated Culture

In this chapter I presented the third layer of my cultural analysis in answer to my first research question. The model on which I framed my analysis reflected my evolving understanding of: firstly, the sense of depth and interconnection even within the outermost, observable level of culture and secondly, the dynamic relationships between the levels of culture. I have framed my discussion in terms of the seven dimensions that I have identified, namely:

- The Engineering way of thinking;
- The Relationship of Engineering to the environment;
- The Engineering identity;
- The Engineering way of doing;
- Time;
- Relationships – Mates and the sense of belonging
- Homogeneity vs Diversity.

I developed these dimensions inductively from my data and my prolonged exposure to my case study institution. These dimensions not only resonated with staff and students at my case study institution, but confirmed and incorporated into the cultural context, behaviours and practices commonly reported in the engineering education literature. The extent of this resonance serves to underline the commonality and enduring nature of international understandings within the discipline of engineering education.

I wove four themes through my findings at each level of my analysis: first, the "hardness" of Engineering with a wealth of understandings around this term; second, the existence of a strong communal sense of identity as engineers; third, a perceived need for mates and belonging for academic survival; and fourth, a readily recognised "way of thinking" that valued pragmatic, quantifiable, open-ended problem solving with real life constraints and top-down methodologies.

Espoused values were however, not always matched by cultural norms. As a consequence I identified tensions and contradictions within the culture such as:

- Conflicting imperatives of serving the needs of academia and the profession;
- The staff desire for deep learning vs. student instrumentalist attitudes in which surface learning prevailed;
- The valuing of group and team work vs. the academic traditions of individualised, ranked assessment;
- A common perception of a mismatch in the valuing of teaching excellence between rhetoric and reward systems such as promotion.

The strength of the shared understandings and enculturation which I encountered in my study echoed for me Hacker's (1989) and later Lee and Taylor's (1996a) arguments that engineering education could be "construed in terms of the production of disciplined subjects" (Lee & Taylor, 1996a, p. 60). I contend that the current model of scholarship in engineering education has been conceived, produced and reproduced in the image of the dominant culture. The behaviours and practices, values and norms and the underlying beliefs and assumptions, for engineering education at my case study institution were initially formed by a culture that was relatively homogeneous with respect to gender and ethnicity. My evidence confirmed that this culture, at every level from basic assumptions to manifested behaviours and practices, is indeed a gendered culture. The masculinity manifested in this culture, I have shown, pervades not only social interaction and discourse, but also the deeper levels of knowledge generation and transmission. Although other ethnic/racial minorities now outnumber white males and females in the student body, white males on the academic staff, by virtue of their numbers and positions of power, are culturally dominant. Despite the confounding complexity of increasing ethnic diversity, not only did the culture of engineering education at my case study institution resonate with values, beliefs and assumptions which have been long identified as masculine, the hegemonic masculinity was that of the white or NZ European male.

My second research question was framed in response to the need, identified in

Chapter 2, to seek further information about the processes of enculturation that shaped students, especially women students, as they learned what it meant to be an engineer. My findings, woven throughout Chapters 4, 5 and 6 and brought together in the previous section illustrate the ways in which students learned how to operate successfully within the learning environment. I noted that, at first year level, no dominant masculinity was perceived by students, and it appeared that a wide variety of gendered behaviours were acceptable. By the end of their degree, however, being an engineer may not have implied "being a bloke", but being accepted as "one of the guys" carried overtones of the norm of masculinity. Within that first year the students had gained a significant understanding of the "engineering way of thinking and doing" even to the recognition of some of the shared assumptions discussed in 7.2.1. A feature of my data, from both questionnaires and interviews with final year students, was the level of enculturation demonstrated by the high level of commonality in themes which cut across both gender and ethnic differences.

By focussing on those cultural norms, beliefs and assumptions which appear to be shared across all engineering sub-disciplines in my case study institution, I have viewed the culture of engineering education as an integrated disciplinary culture. It became clear to me, however, as my analysis progressed, that I also had evidence of subcultures and potential fragmentation. An increasingly diverse student and staff body, physical separation and increasing size leading to closer contact within smaller groups, combined with variations on emphasis and focus in "ways of knowing" between sub-disciplines, enabled members of the culture to recognise the possibility of cultures within the overarching engineering education culture. Moving from the integrated perspective of a single homogeneous culture to a differentiated perspective, looking for distinct subcultures, as mentioned in Chapter 2, has been seen as fruitful (Frost et al., 1991) to gain a more complete picture of a culture.

My third research question was therefore framed from this differentiated perspective. In the next chapter I consider engineering education in terms of sub-disciplinary cultures, as "cultures within the culture", with a particular focus on why some sub-disciplines persistently attract higher participation by women, whilst participation in others remains obdurately low.

# Chapter 8

## Cultures within Cultures

### 8.1 Purpose and outline of this chapter

As foreshadowed in the previous chapter, my observations and data confirmed for me the existence of subcultures within Engineering education. Further, I considered that exploration of these subcultures could provide insights into the persistence of differences in female participation between the sub-disciplines of Engineering and the wide variety of experiences, both social and academic, amongst female students and staff. The purpose of this chapter is therefore to present my analysis of sub-disciplinary subcultures. This analysis highlights examples of those cultural features that might be barriers to the higher participation of women in engineering education. It also reveals inclusive cultural features, which are welcoming, not only to women, but also to a wide range of potential engineering students.

Although I carried out an in-depth analysis of each sub-discipline, the initial findings of which were reported in two conference papers (Godfrey, 1998b: Godfrey & Parker, 2001), the detail of that full analysis is beyond the scope of this study. In this chapter I have therefore extracted from that analysis those findings which contribute directly to a better understanding of the relationship between the cultural features of the sub-disciplines and gender, particularly the implications for women's participation. In so doing, I answer my third research question:

- Viewing sub-disciplines as subcultures within the culture of engineering education in the case study institution, how do these subcultures interact with gender?

In the next section, I provide background information about the sub-disciplines at the case study institution, and the links between their role as subcultures and women's participation. Explanations have been given by a few authors such as Byrne (1993) and Cobbin (1995) (see section 1.3.3, p.12) for the persistent variation in sub-disciplinary female participation. To provide insights which might disrupt these patterns, in the following sections I have deconstructed some of these explanations by treating the engineering sub-disciplines as cultures within the overall engineering education culture. I use my framework of cultural dimensions, developed in Chapter 7, to discuss cultural features in my case study institution that appear to be particularly relevant to the persistence of differential female participation.

## 8.2 Sub-disciplines as subcultures

In Chapter 2, I suggested that Engineering as an academic discipline was itself a subculture of the overall higher education culture. In section 5.7 I presented the results of staff responses to my request to position Engineering diagrammatically as a subculture lying across the boundary of the wider university culture. I also asked the staff for a diagrammatic representation of their perception of possible subcultures within the School of Engineering. Their answers included: staff and students; academic, technical and administrative staff; ethnic groups; undergraduate and postgraduate students; and different departments or sub-disciplines. This feedback confirmed my own observations that subcultures existed within the overarching engineering education culture, formed by prolonged close proximity and common problems and goals. While it is likely that an analysis from the perspective of any of these subcultures would add more information to our understanding of a complex cultural picture, I have chosen to focus on the engineering sub-disciplines, because of the links between these sub-discipline cultures and the participation of women.

My interest in sub-disciplinary cultures was initially provoked by my interviews and surveys with the graduating classes of 1996 and 1997. These highlighted markedly different experiences and outcomes for female students. I observed academic differences such as what knowledge was valued, the strength of focus on mathematical solutions and the “provable”, the extent to which social and environmental issues were viewed as “real” engineering and other such pedagogical issues. In addition, my data showed that measurable factors such as class size and the homogeneity of the class in terms of age, gender and ethnicity, as well as intangible factors such as the nature of relationships, had the potential to impact on the culture that developed within a sub-discipline.

At my case study institution, Civil, Mechanical, and Electrical Engineering were the most traditional and well-established disciplines, with international as well as national professional associations.  That background appeared to be linked to entrenched beliefs and assumptions about curriculum content, pedagogies and professional issues appropriate to each discipline. Chemical Engineering was newer (first taught as a separate discipline at the U of A in 1967) but was also an internationally recognised sub-discipline. The Department of Engineering Science (known in its earlier years as Theoretical and Applied Mechanics) was a younger (approximately 20 years old) and less traditional sub-discipline, but with full professional accreditation. The new sub-disciplines of Resource Engineering and Computer Systems Engineering, offered for the first time in 1998 and 1999 respectively, were offshoots of well-established departments (Civil and Electrical) and did not appear to have developed separate cultural identities at the time of my study.

Both staff and students made generalisations and perceived stereotypes related to the sub-disciplines:

*We are all engineers but the departments are like different tribes* *Sstaff10, Oct 98*

The persistence of sub-discipline cultures appeared to be considerably aided by the high proportion in some departments of long serving staff, and in others, by the significant number who had been former students. The senior staff had taught and later mentored many of the junior staff, who were themselves transmitting cultural values and norms to another generation of students.

### 8.2.1 Trends in female participation

The statistics provided by Byrne (1993) and Cobbin (1995) confirmed enduring discipline and institutional differences in female participation, with some disciplines remaining obdurately unattractive to women despite marketing and affirmative action programmes. Further, and as I predicted at the outset of my study, female participation since 1998, at undergraduate level at the U of A School of Engineering, appeared to have plateaued at 20%. This plateauing mirrored international trends (Committee on Women in Science, 1993; CuWaT, 1998; Lewis & Harris, 1995; Vetter, 1996).

Table 8.1 provides further details of female participation at the School of Engineering over the time of my study, showing increases in some disciplines and gradual decreases or no change in others, with a range of participation by the year 2000 from 11.1% in Mechanical Engineering to 45% in Engineering Science.

Table 8. 1 Female Participation at U of A by Engineering sub-discipline 1995 – 2000

| **Year** | **C&M** | **Civil** | **CompSys** | **E & E** | **EngSci** | **Mech** | **Resource** |
|---|---|---|---|---|---|---|---|
| 1995 | 32.1 | 23.6 | - | 16.6 | 19.6 | 8.1 | - |
| 1996 | 37.4 | 22.7 | - | 15.2 | 17.7 | 9.7 | - |
| 1997 | 34.3 | 25.3 | - | 10.9 | 21.2 | 11.3 | - |
| 1998 | 37.6 | 24.4 | - | 11.7 | 25.0 | 10.9 | 40.0 |
| 1999 | 37.0 | 21.6 | 10.9 | 12.5 | 36.1 | 11.0 | 42.9 |
| 2000 | 38.0 | 20.5 | 13.8 | 14.2 | 45.0 | 11.1 | 41.5 |

At the time of my interviews with senior students, 1996 and 1997, only one sub-discipline (Chemical and Materials Engineering) consistently had female participation figures (>30%) at levels that Byrne (1993) deemed "sex normal" for both sexes and might therefore be considered sex-neutral. By the end of the 1990s female participation in Engineering Science had also reached and surpassed that level. The level of participation in these two sub-disciplines, combined with my observations, suggested to me that they might have some features of inclusive disciplinary cultures.

The participation in Civil Engineering, on Byrne's classification, could be seen as "*untypical* but sex-normal" (16-29%) for the minority (female) sex, whereas the level of participation in Electrical and Mechanical Engineering was closer to "*abnormal*" for female students. Alongside the long-standing low levels of participation of women in Electrical and Mechanical Engineering, my data suggested inconsistencies in their experiences. Over a number of years I observed competent, confident young women graduating from Mechanical Engineering. They contrasted with women from Electrical Engineering who often lacked confidence in their own ability and thought of their degree only in terms of survival. Other contradictions arose – including my perception that, within the overall masculinity of the engineering culture identified in

Chapter 7, a range of masculinities seemed to be evident when comparing the behaviours and practices of, for example, Civil Engineering and Electrical Engineering.

The participation statistics shown in Table 8.1 appear to confirm two of the generalisations reached by Cobbin (1995), discussed in Chapter 1, that female participation was:

- higher in relatively small fields of study;
- higher in courses with chemical and life science orientations.

However, I found contradictory evidence in my case study institution to another two of Cobbin's generalisations, namely that participation was:

- lower for less prestigious courses (lower entry requirements); and
- lower in courses with a hard core computer programming emphasis.

In the following sections I will analyse relevant aspects of the sub-disciplinary cultures, using the cultural dimensions that I identified in Chapter 7, to throw light on the source of my observed contradictions and the cultural behaviours and practices which are associated with higher and lower levels of participation and performance of women.

## 8.3 Interaction of gender and subcultures

Sub-disciplinary participation starts with sub-disciplinary choice. Whilst sub-disciplinary choice was not a focus of my study, I had evidence to suggest that all female students who were attracted to engineering had above average confidence and ability in mathematics and science. Having made the decision to study engineering, their choice of sub-discipline sometimes appeared to have been serendipitous, and swayed by chance acquaintance or even a process of elimination:

> *…he told me if you really like to do physics you can do engineering especially with electrical – they are all concerned with physics* *Stella, 4th year E&E 1996*

> *…it was sort of like – like I wasn't looking towards engineering from the beginning , it was more like I didn't want the other options* *Chloe, 4th year Mech 1996*

*I thought I'll take Engineering to prove to myself that I can do something that looks quite hard in the first place, and Eng Sci had lots of maths*
*Colleen, 4th year Eng Sci 1996*

*Came to Enginuity day in the seventh form and originally was looking at Eng Sci but didn't like their display on Enginuity day and like the Electrical one so thought that would be better* *Amy, 4th year E&E 1996*

Sub-disciplinary choice also appeared to be linked loosely to two factors. The first was "interest", which I suggest was an almost unconscious alignment of their perception of a discipline's "way of thinking" with their own, although it was evident from my data that this perception was often quite inaccurate:

*…my interest in chemistry – I didn't realise that C&M engineering wasn't chemistry oriented. I think that is a mistake most students who go into chemical engineering make.*
*Karol, 4th year C&M 1996*

The second factor was "career potential", which was a motivating force for many students:

*The reason I chose engineering was because I knew there were a lot of jobs available in New Zealand and the honest truth is that I knew there were pretty good jobs available for the electrical engineers and I knew I could make a reasonable career out of it.*
*Geetha, 4th year E&E, 1996*

*I just felt it would get me a job, and once you are in there you have some more opportunities to find what you really want to do* *Heather, 4th year E&E, 1996*

Female students rarely spoke of entering engineering with a commitment or passion for one particular sub-discipline. Not all male students were as committed as Laurie who commented "I was born to be an engineer" (Laurie, 1st year student, 1998) but it was not uncommon for the male students to enter with a passion or commitment to a specific sub-discipline as these comments evidenced:

*I am another step towards fulfilling my dream. Imagine a world of robots, cyborgs, and humans, living together.* *Simon, 1st year student, 1998*

*I love aesthetics, and buildings and things and …I wanted to understand the underlying form of everything, in terms of the forces, and the physics, not just how it looks*
*Angus, 1st year student, 1998*

*I'd always thought id like to get into yacht design* *Joshua, 1st year student, 1998*

I now examine the cultural features of the sub-disciplines using the dimensions identified in Chapter 7 within which shared beliefs and assumptions had formed.

### 8.3.1 The Engineering way of thinking

Hacker (1983) and Byrne (1993) had linked lower female participation in sub-disciplines with a heavy content of mathematics, to masculinising of disciplines. As

I reported in Chapter 7 (7.2.1), mathematics was an integral component across all disciplines of engineering in the way knowledge was accessed, valued and assessed, and engineering analysis and design were performed. My evidence suggested however, that the role and importance of mathematics within the sub-disciplines differed sufficiently to give rise to comments such as the following:

> *I started out in E&E and I bombed, and I was advised to do Civil because it had less maths in it – less maths content therefore it must be easier. I thought of E. Sci, but everybody thought E. Sci was hard because it had all that maths in it.* *Trish, 3rd year Civil 1997*

Trish's comment was representative of a common belief that the level and role of mathematics was one of the criteria that established status and contributed to a perception of the hard/soft positioning of a sub-discipline. The same sort of beliefs appeared to be held around the relative hard/soft nature of courses even within a sub-discipline:

> *Although we all focus on applying knowledge and use mathematics for analysis and modelling, there is definitely a difference in the department in the way we view subjects like Control, Thermo, Strength of Materials …which require mathematical analysis and are dominated by people with mathematical strengths and the more practical ones like Management and Manufacturing – their analysis is also complex but sort of more wordy and descriptive. They don't command the same respect and aura. I would tend to send a poorer student towards the Project Management side.*
>
> *Sstaff10, feedback, June 2001*

When I began my study, Electrical and Electronic Engineering was the department that might have been seen to epitomise Byrne's link between maths and low female participation. Participation in Engineering Science, however, appeared to refute this link. Although only a small department, female participation increased through the late 1990s to a level of 45%, with women emerging as high achievers and emphatically positive about both their academic and social experiences in the discipline. Yet Engineering Science was almost totally focussed on mathematical modelling using computer simulation.

The use of mathematics in Electrical Engineering was perceived as dominated by manipulation, derivations, and proofs, rather than just application of formulae:

> *…like in electrical engineering you want to do something you have to do all this maths to figure out what you are going to have to do.* *Richard, 4th year E&E, 1996*

> *The vast advances in digital electronics… upped the stakes on the maths considerably …our students always used LaPlace transforms in terms of solving circuits that have got transient behaviour but the related Fourier transforms were only encountered in graduate work, now routinely used in an undergraduate course*
>
> *Sstaff1, feedback July 2002*

Many of the courses offered were seen as the theoretical underpinnings of the knowledge, including the mathematical techniques, which would allow the students to understand, analyse and design, rather than be "black box technicians":

> *Signal processing, image processing, those subjects aren't ends in themselves, they are about developing mathematical tools that get used in other courses* *Jstaff1, Jan 98*

> *… we have gone for a system here where we think students really need to know what is going on inside and can design it. But to understand what is going on they have to do some mathematics.* *HOD1, Jan 98*

It was common in these courses to see pages of lecture notes without a single word of English, but combinations of mathematics, and diagrams. The language of Electrical Engineering (see also 6.4.1) clearly involved both mathematics and the visual/symbolic images, rather than words, which were seen, as indicated below, to be less efficient:

> *We could use words but it would take a lot of words, so in a sense we are using a type of shorthand. Graphs are a good way of showing trends, formulae show relationships, and increasingly flow diagrams to represent the logic by which you do things …all just very efficient ways of trying to convey the interrelationships between a complex range of parameters* *Sstaff1, feedback, July 2002*

Electrical Engineering used high order mathematics and a variety of visual images to analyse and solve complex but intangible systems requiring a high degree of abstraction. This was seen by staff as in contrast to disciplines such as Civil Engineering in which mathematics appeared to be used in more of a "plug in the formula" way.

> *EE that is more polarizing now than in any of the other disciplines in the sense that – partly the maths and the specifics of it, but also partly the development of the skills of analytical thinking that are important and I would have thought that is not so true in Civil where the maths is means to an end of working out what the forces and stresses and how big the beam needs to be.* *Sstaff1, feedback, July 2002*

I inferred from a number of sources that mathematics and computing were dealt with differently in Engineering Science. Masculinity has been allied to precision and certainty (Lloyd, 1993). The ability to visualise more than one solution, when working with mathematical and computer models and "best" solutions, commonly encountered in Engineering Science, might therefore be said to be allied to femininity. Engineering Science, with its branches of Operations Research and Biomedical Engineering, attracted high numbers of female students for whom mathematics held no fear. Mathematics was seen these students as the tool that opened the doors to problem solving and modelling that required innovative and quite creative thinking. The modelling of real life, identifiable problems such as tidal flows, electrical activity round the heart, and fluid flow round sails was accessed through very specialised computational mathematics techniques. These were applications seen by students as useful to people and challenging intellectually:

> *I always connected so much of the work going on in E. Sci back to people – the environmental fluid mechanics, the geothermal work – I wanted to do something that was about people rather than just equations on a page.*
>
> *Rose, new graduate Eng Sci 1997*

Therein, I propose, lay the attraction Engineering Science held for female students and others who sought a connection with the material they were studying. The application of high level mathematics appeared to be seen in Engineering Science as not only intellectually challenging, but also useful to people, whereas in Electrical Engineering the high degree of abstraction and intangibility of the outcomes appeared to mask connective links for many of the students.

Cobbin's (1995) statement that female participation was lower in those disciplines with a high content of "hard" core computer programming was not a systematic trend in my study. Low participation in Electrical and Computer Systems Engineering, relative to higher participation in Civil and Chemical Engineering, appeared to confirm this perception. Again, however, Engineering Science, in which almost all of the high level mathematics was utilised in conjunction with computer modelling (resulting in a very high component of programming in its courses) appeared anomalous. Forces other than an attraction or repulsion to computing were clearly affecting participation in the latter discipline.

These disciplines illustrated for me that a simplistic linking of low participation with high content of mathematics and computing, particularly by those writing from outside engineering such as Hacker (1983), did not take account of the role and contexts in which mathematics and computing were used. As demonstrated in the following brief discussion, I saw it as more helpful to look for explanations in linking concepts of separate and connected knowing (Baxter-Magolda, 1992; Belenky et al., 1986) with the sub-disciplines.

In section 7.3.1 I discussed the linking of separate knowing, engineering and masculinity with the proviso that the focus in engineering on real life applications created openings for those who might be more comfortable with connected knowing.

The goal across all disciplines was to put engineering content into real life contexts. Comments such as the one by SStaff10 earlier in this section, however, with its implication that a "poor" student" was one with low ability in mathematics, matched my perception of the dominance and higher value placed, not only on courses with higher level mathematics, but on separate knowing. The more respected and "hard" engineering across all disciplines appeared to be taught in a "*pretty dry manner*" and was perceived by students as theory or concept oriented, accessed via mathematical tools, and not well linked to context or use. Difficulties were experienced by those students who needed to feel "connected" to the subject matter they were trying to understand:

> *I couldn't like Solids at all because I just can't picture stress in a beam and I can't understand I can't really visualise it and I just yeah... and with fluids and looking at cycles in a steam plant I could see how it would be useful*
>
> *Chloe, 4th year Mech 1996*

A preference for connected knowing appeared to be the explanation behind Cobbin's (1995) generalisation that higher female participation was observed in those disciplines which dealt with chemical and life sciences. Chemical Engineering (with its consistently higher than average female participation) and Civil Engineering both dealt with tangible outcomes that appeared to be accessible and connected universally to real life experience:

> *Most of us can have a reasonable discussion with a Civil about the new building being built next door but if we get into a discussion on electromagnetic radiation or interference or whatever because you can't actually point to it, it requires a language and a set of concepts that one can't make that kind of constructionist leap*
>
> *Sstaff1, July 2002*

The content of the Civil Engineering curriculum was a mix of structural design and analysis, transportation, public health and environmental management. As with any academic discipline, Civil Engineering had its own technical jargon, but the potential for "connection" with the subject matter appeared to be important for students like Trish:

> *Civil is more real in terms of what people experience every day – like you have pegs you can hang things on. You couldn't necessarily read an environmental mechanics exam but someone could explain it to you …you can make connections…*
>
> *Trish, 3rd year Civil 1997*

Several of the students to whom I spoke had chosen Civil Engineering because of an idealistic view of its potential to enable them to "make a difference" and "change the world" (or at least one part of it) and, in particular, be able to see the outcome of their efforts:

> *…like my friend Emily, she always wanted to do Civil, to build bridges and make a difference…* *Rebecca, feedback April 2000*

The new sub-discipline of Resource Engineering with its strong content of Environmental Engineering attracted almost 50% female participation, although the discipline was too new, and numbers at the School of Engineering currently too small, for the discipline to be considered separately in my study.

Electrical Engineering, compared to other disciplines that dealt with tangible outcomes, often seemed to be concerned with less visible or accessible concepts and products. I found a preponderance of terms such as impedance, resistance, bandwidths and signal processing, that were accessible only to those with the same training, and I suspected that this may have contributed to a sense of isolation and difficulty in communicating with non-electrical engineers:

> *She told me she chose to do a particular final year project to study how tumours can be treated by controlling the electronic field …because it was something she could easily explain to her family and friends …whereas if she told them "I am learning linear systems or doing Fourier analysis" – their eyes glazed over and she felt like an alien*
> *Jstaff4, Oct 97*

> *Electrical has moved from dealing with physical identifiable artefacts to a more abstract realisation – intangible – still definable, measurable and quantifiable… …Many of the students become detached because the connection between the subject they study and the application is being stretched…*
> *Sstaff1, feedback July 2002*

The lack of connection felt by many of the female students in Electrical Engineering, even those earning high grades, leads me to suggest that this abstraction and the intangible nature of many of the "products" of electrical engineering were largely responsible for the initial lack of recruitment of women to this discipline and the lack of commitment evidenced even by those who completed the degree successfully.

### 8.3.2 The Engineering identity

I have earlier identified the masculinity of the beliefs and assumptions around what it meant to be an engineer (7.3.3), and gendered behavioural norms (6.6). I have referred earlier to the work of Connell (1995) on the construction of masculinity. Relevant to this study were his reminders that masculinity was not a singular phenomenon and in any group some masculinities were likely to be valued more highly than others. From evidence gathered in interviews and my extended observations, I concluded that there were marked disciplinary differences in constructions of masculinity. The dominant masculinity in Civil Engineering (and to a lesser extent Mechanical Engineering), for example, was quite distinct from that found in Electrical and Electronic Engineering.

The dominant masculinity in Civil Engineering, "the good Kiwi bloke", appeared to closely match the conservative, traditional NZ masculinity described by Phillips (1996). The discipline had a long history of male dominance and it had only been in the last 10 years at the case study institution that female participation had risen out of the "rubric of exceptions" (Byrne, 1993, p.13) or token level. It was, however, a discipline with contradictions. From time to time it had provided the worst instances of sexism and male chauvinism of all the disciplines, yet the majority of female students appeared to emerge confident, articulate and connected strongly to their role as potential professional engineers.

In Civil Engineering, to be male was very much the norm, and this was apparent in the use of language, which habitually included male examples:

> *It really blew me away, the lecturer was a female and she was talking about management issues in Civil Engineering and she just kept saying "he, he, he…" – I mean I didn't expect it from her* *Trish, 3rd year Civil, 1997*

> *Some lecturers were obviously reluctant or irritated that they had to change their language. Seemed to be a function of their age …and background*
> *Sean, new Graduate Civil, feedback Nov 2000*

Humour of the "male bonding" type was prevalent, emphasising again that being male was the norm:

> *Lots of sniggering, always talking about rigid members and that sort of thing …Discipline had all these lovely words with double meanings – I didn't find it a problem …unless they turned round and apologised…* *Trish, feedback Nov 2000*

Civil engineering students, both male and female, were always strongly represented in the Engineering Students' Society, and often took leadership roles. There seemed to me to be a contradiction between the image or stereotype of a Civil Engineer and the day-to-day reality as evidenced in Trish and Samuel's comments:

> *I think the key thing was that people expected it to be – so like you get a lot of pressure – you guys are Civil you' re going to be like this – the individuals probably didn't fit the stereotypes but when they got together there was a pressure to act a certain way… if you are going to be an engineer and you consider yourself a bloke already – you know the rugby drinking sort – you are not going to go off and do some sort of namby pamby thing like electrical…* *Samuel, new graduate Civil, 1997*

*…there is a kind of mismatch between the image and reality – image blokey macho – you will see things that reinforce that image but if you looked at the sum of all of the activity – they are not blokey macho 99% of the time, have only a few reinforcing the image – if you look at any one individual they really weren't – it was the stereotype…*
*Trish, feedback Nov 2000*

This contradiction, between the stereotype and the day-to-day reality, appeared to provide the space for female students to be accepted and participate as members of the group. I noted over the years that female students from Civil Engineering consistently appeared to be self confident, articulate and willing to take on leadership roles:

*When I look at the women in my class, they did have what I call masculine traits – sort of get in there and do it – if they didn't like something they would say so, very blunt…*
*Trish, 3rd year Civil 1997*

*Some of the girls in my class definitely identify with the bloke thing – and are more inclined to be 'one of the boys' – but that is not the whole picture. I mean the Asian women weren't like that – they do defer to the guys more than we do, but they seem different to the girls in electrical – more connected somehow*
*Rebecca, feedback April 2000*

Success in Civil Engineering required adaptation to the department's masculine behavioural style, which I proposed was more easily accommodated by those young women familiar with traditional New Zealand masculine behaviour. The confidence with which the female students spoke out against examples of perceived gender-related or other injustices seemed to me to imply a high level of personal self confidence, but also a perception of sufficient support from staff and their peers.

Mechanical Engineering offered a similar picture, with a consistent male:female ratio of 9:1. Learning styles, humour, background, and behaviours were assumed to be those of the male students and it appeared to me that equity in this discipline meant accepting females who met the same criteria as males i.e. they conformed to male norms. The female students whom I interviewed and observed over several years fitted into the prevailing culture, with little protest. One realised (on reflection after our interview) that she had adapted her behaviour to fit the environment:

*Funny thing though… I have noticed that when I'm working in an engineering context I take on a whole different persona. It's still me… crude, blunt, intelligent, etc. but my voice seems to be lower and my stance and posture would be more masculine (I guess you can say that). I found that the attitude I present helps others to take me seriously as an engineer.* *Julie, email feedback July 1997*

*I guess with a daughter of about the same age, I have noticed the group of girls who are third year now – several of them started out real individuals, now they are sort of like 'groupies' – they sort of merge in with the guys in dress (scruffier) and behaviour, kind of lost their femininity, outwardly at least.* *Sstaff10, feedback, June 2001*

In contrast, not all the attributes and qualities mentioned in 7.2.3 as inherent in being an "engineer" applied to Electrical Engineering staff and students, particularly the traditional "blokey" stereotype of the "partying, drink hard" engineering student. Ability in mathematics and, increasingly in more recent years, skills or confidence using computers and programming were generalisable attributes that were associated with staff and students in this department. The image of Electrical students as "geeks", implying a narrowly focussed, clever, but physically unprepossessing student, with an almost obsessive interest in computers, was prevalent in the perception of Electrical Engineering students by themselves and others:

> *By necessity, in terms of work habits you really have to be what other faculties describe as a geek* — *Brett, 4th year E&E 1997*

> *Nerdy, geeky comes with the nature of the discipline, seems more remote – so much is not able to be realised or shown in simple terms* — *Sstaff1, feedback July 2002*

These were the engineers who were likely to be Star trek enthusiasts:

> *…it is almost like a requirement if you are an engineer you have to be a big science fiction fan, yes, in this department especially – my integration would have been better if I was a Trekkie* — *Jstaff4, Oct 97*

or computer gaming fanatics found in the computer labs late at night:

> *Mostly real people but there are quite a few people who love their computers. Their idea of a good weekend is getting six guys together with their computers and networking them and playing Doom* — *Brett, 4th year E&E, 1997*

In section 7.2.3 I spoke of the self-reliant, self-capable strength of character that seemed to be a quality present or developed by those who might be deemed successful engineers. Several staff made comments such as these, in relation to the personal outcomes for Electrical Engineering students:

> *What worries me is that they come out the other end of the electrical department quite demoralised and when I see students in other departments they come out more enthusiastic.* — *Jstaff1, Jan 98*

> *We seem to turn silk purses into sows ears instead of the other way round* — *HOD1, Oct 97*

My particular concern was for those female students from this discipline who, when questioned about their experiences through the degree, used comments such as these, which were illustrative rather than singular examples:

> *I no longer believe in myself* — *Questionnaire F6 1997*

> *I personally felt it was a little too taxing for females* — *Questionnaire F6 1996*

> *I could never get passionate about engineering. I don't think anybody could.* — *Miriam 4th year E&E student 1996*

In contrast to the distinctive hegemonic masculinities within Civil and Electrical Engineering, disciplines such as Engineering Science and Chemical Engineering appeared to manifest a range of masculinities. Although Chemical and Materials Engineering had a predominantly long serving male staff, the reasonably high level of female participation over a number of years appeared to have led to an environment in which women were treated as individuals, rather than generalised as a group. From a student point of view the male staff were seen as rather bland and conservative:

> *Our lecturers have been there a long time – yeah, I can't think of many other ways of describing them – straight, boring and conservative – there seems to be a few more nippy ones starting* *Karol, 4th year C&M 1996*

Again, Engineering Science was an anomaly. Staff were younger than in most other departments, and included one (sometimes two) female lecturers, and a higher than usual proportion of staff with backgrounds from outside engineering (such as applied mathematics or statistical backgrounds). Staff from this department taught in the cross-disciplinary Mathematical Modelling and Introductory Computing courses and therefore all students were exposed to them at first year level. "Hard driving achievers" and "really good problem solvers" were terms applied to the staff:

> *The heroes in the dept I am in seem to be people with finely honed skills who can pose or solve tricky problems.* *Jstaff6, Jan 00*

> *This department is pretty kind of uncompromising in terms of hard driving standards, there are a lot of A type males all trying to achieve and working very long hours*
> *Sstaff2, Jan 98*

but also images of athleticism, and friendly informality abounded:

> *M… is really cool …she has a real give it a go attitude, she says funny things, not afraid to think" I am so cool…"* *Jaya, 1st year student 1998*

There appeared to be a perception of elitism in terms of their mathematics ability, but students from this department never spoke of the discipline as "macho" and I observed a very comfortable use of gender inclusive language, with very little crass or sexist joking. The department had been a major supporter of affirmative action for women in engineering for close to twenty years.

Another attribute of engineers that I discussed in 7.2.3 and 7.3.3 was the assumption that engineers were practical "can do" people. I inferred from my evidence that the "heroes" of "real engineering" were associated with Design, in which male students were perceived as being advantaged. This attribute was particularly apparent in

Mechanical Engineering which focussed not only on theoretical scientific knowledge, but also on the ability to use that knowledge in Design and problem solving. A very practical, "can do" attitude appeared to be valued, and although a background which included some "tinkering" experience was useful and helpful in recognising terminology and applying theory, it was recognised that the current student body did not all have that background:

> *Seems to be a sentimental longing for students who used to help Dad repair the car – we say students don't tinker any more but they do, they tinker with computers but it is not a mechanical type of tinkering.* *SStaff3, Sept 00*

The majority of the women I encountered in Mechanical Engineering, both from the 1996 group and in later years, were lacking in the directly relevant "tinkering" experience that their male peers spoke of:

> *I found it very difficult as a girl from a single sex school not having any practical application of knowledge like motors and bearings. I think most boys at school get a definition of something and then a practical application of it.*
> *Questionnaire F19, 1997*

They were aware that lecturers made assumptions, as these comments illustrated:

> *I was not used to mechanical concepts and things but there were a lot of assumptions in the way we were taught… it was …"things were obvious" or an example …was something related to a car engine or something that you were expected to be familiar with and I was just getting lost…* *Chloe, 4th year Mech 1996*

> *Terminology and jargon which all males seem to attain at birth was not always easily grasped* *Questionnaire F9, 1997*

The "heroes" of Design courses and competitions were almost always male students, and it was my perception that, although women students enjoyed design courses, I had not observed the same level of commitment and passion from them as from their male peers.

In Electrical Engineering "practicality" was linked to familiarity with electronics and computers, rather than any hands-on exposure to cars, machinery or construction. Female students, even the highest academic achievers, almost unanimously perceived themselves as lacking, compared to their male peers, in computer and electronics skills and experience:

> *I think they (male students) are a little less frightened of the whole technological twiddling knobs, fiddling with the oscilloscope, building…*
> *Melanie, new graduate E&E 1997*

> *… some of the guys in our class had little labs set up in their house whereas I wouldn't think of that as my hobby* *Geetha, 4th year student E&E, 1996*

*I think the guys had, most of the guys – well sometimes they get to know a lot more about little things than the girls do… like computer architecture and hardware and lots of little things like that.* *Miriam, 4th year E&E student, 1996*

In contrast, several of the male students to whom I spoke had hobbies or interests that may have led them into electrical engineering, such as tinkering with electronics kits, theatre lighting and a passionate interest in computers.

Although, as stated in earlier chapters, Design was an essential and valued component in all of the degree courses, a reliance on prior practical knowledge or tinkering experience did not seem as essential in disciplines such as Engineering Science or Chemical Engineering, with the majority of courses new to all.

### 8.3.3 Hard/Soft Engineering way of doing

The belief that engineering was "hard", as I had identified in 7.2.5, was nowhere more evident than in the shared understandings of students in Electrical Engineering. Electrical students constantly repeated "*we had it the hardest of anyone*" when comparing themselves to students of other disciplines.

The perception of difficulty with the course content was confirmed, for the students, by pass rates that were, on a regular basis, the lowest across all disciplines. These low pass rates were a cause of concern for both students and staff, especially considering that these students could be shown statistically to have the highest average GPA across the common first year. Within the scope of this study, I was not able to examine more closely the contributing factors to this perceived underachievement although I suggest it was closely linked to the degree of abstraction and complexity which was seen as "*higher than in any other discipline" (*Sstaff1, July 2002*).*

A prescribed, inflexible curriculum, in the second and third years, with a heavy content of theory and technical knowledge was a shock to able students who had always achieved well:

*I found all of a sudden I had to work hard to do well – not so much to do well, but just to get through – real dramatic change for me. Everything was difficult; most of the papers were hard…* *Geetha, 4th year E&E student 1996*

The "challenge and stretch" teaching paradigm, particularly in Design projects, was commonplace, although staff tried to ensure that this was not manifested as “sink or swim”:

> *Staff involvement is most intense and the aim is that every student should succeed. Students feel they are thrown into the deep end and left to swim – well not quite like that. The only way to learn is to gain experience but we aim to help them all the way through.* *Sstaff6, Sept 00*

The students’ perception that they had the highest workload may have been enhanced by the long hours spent in-house using specialist equipment and computers for these projects:

> *…but in third and fourth year you had no time to go outside. We had all our meals here, do everything here, even sleep here sometimes* *Mei, 4th year E&E student 1996*

Female students, as I commented in 7.3.4, appeared to be particularly unfamiliar with this teaching paradigm. Despite their retention at rates equal to their male peers they frequently used words like “survival”, “struggle” and “stress” when discussing their experiences and conveyed little enthusiasm for the discipline or future employment as Electrical Engineers.

As discussed in 7.2.4, perceptions of high workload, on-course assessment, and the “challenge and stretch” teaching paradigm were widespread throughout all disciplines, and each discipline seemed to take pride in proclaiming that theirs was a tough course. I have also commented earlier on the prevalent linking of “hard” courses to those with a high content of mathematics. Although no discipline wished to be seen as “soft” or “easy”, staff in Civil Engineering, which contained courses such as Resource and Project Management, History of Engineering and Public Health (which provided opportunities for writing, logical thinking and debating issues), identified these courses as of more interest to women. The skills required in these subjects were seen as generic professional skills rather than feminine, but there did appear to be a tacit understanding that they were easier than the more mathematical courses:

> *Some parts of the courses interest the women more. I am involved in resource management and environmental assessment of environmental effects and… transportation and I find the girls are often more interested in that and the boys are interested in cars going round on the super elevation* *Sstaff4, Jan 98*

### 8.3.4 Relationships

In Chapter 6 I provided many instances of the effect of close proximity, class groupings and working in project groups on the formation and importance of student relationships. In section 7.2.4 I emphasised the belief that task-oriented supportive relationships were an academic necessity across all engineering disciplines. The essential feature of these student relationships, for the female students in particular, was that a supportive group of friends existed, which may or may not have included other women. The examples I have provided in this section illustrate that female students responded to sub-disciplinary differences in class size, gender balance and ethnic diversity to form and sustain a supportive niche for themselves.

For the second, third and fourth years of the degree, each class moved as a group, with smaller classes in each discipline likely at fourth year when choice amongst electives was possible. Average class sizes and female participation for the period of my study are given in Table 8.2.

Table 8.2 Average Sub-discipline class size and participation 1995-2000

| **Sub-discipline** | **Class size** | **Average female participation** |
|---|---|---|
| Chemical and Materials Engineering | 30 | 36.0% |
| Civil Engineering | 80 | 23.0% |
| Electrical and Electronic Engineering | 90 | 13.0% |
| Engineering Science | 30 | 27.5% |
| Mechanical Engineering | 80 | 10.5% |

Another of Cobbin's (1995) generalisations, that small fields of study were more likely to attract higher female participation and positive experiences than those with larger classes, appeared to be true for disciplines such as Chemical Engineering and Engineering Science. Each of these disciplines had a history of higher female participation, which, in itself, may have been a contributing factor, as female students were perhaps unconsciously recognising that "like attracts like" and that they would be welcome and accepted in these disciplines. Smaller class sizes were seen as providing the opportunity for closer relationships to form, and a sense of "family" was more evident, which was valued by students of both sexes:

*Chem & Mats had a small close-knit class feel, involving group unity, helping each other, and discussing work and all sorts of weird and wonderful engineering concepts*
*Ruth, new graduate C&M 1997*

*The atmosphere in E. Sci was also great – the faculty were all neat people who were really interested in us as people. Classes were small so there was a lot of interaction between faculty and students* *Rose, new graduate Eng Sci 1997*

*Our class worked together well, everyone got on with everyone, they talked with each other and helped each other* *Dave, 4th year Eng Sci 1997*

In the Engineering Science department key personnel appeared to have role modelled for students an informal, "laid back" relationship style alongside academic expectations of high achievement and commitment. Staff were often known in Engineering Science by first names and the familiarity of smaller class sizes enabled them to see students, especially in their final years, as potential colleagues:

*I think that one of the more important reasons for this culture is that there is not a clear discontinuity between staff and students, particularly as they go up through the school. The fact that year 4 students often do valuable work in their projects and are appreciated for it and that the grads are an important part of the research of the school and this is publicly recognised means that there is a feeling of all working together.*
*Jstaff6, Jan 00*

Sub-disciplines with a low percentage of women, however, appeared to provide varying experiences and outcomes, confirming Lantz's (1982) argument that critical mass theories could not be used to predict performance or satisfaction for women.

The 1996 female students of Mechanical Engineering were positive and enthusiastic about their role as engineers and, academically, were at least as successful as their male peers, if not more so, in most aspects of the course. I saw the key to the positive outcomes for this group to be their social acceptance and integration within the class and School environment. Contributing factors to this integration appeared to be the matching of their personal values emanating from similar socio-economic, educational and ethnic backgrounds to those of their male peers. The 1996 Mechanical Engineering class had the highest proportion (amongst the sub-disciplines) of NZ-European male students, and all six of the women were NZ-European or NZ-born.

The Mechanical Engineering women had found within their large class, supportive friendships with their male classmates "*couldn't have got through without them*", rather than with other women:

*I couldn't say that we (the women) did stick together, two of them were good friends but most of us weren't a clingy group… I've always got on well with the guys, and I've sort of been closer to the guys in my class than the girls.* *Chloe, 4th year Mech 1996*

Although they all expressed a high degree of comfort in their environment, each of the women students knew exactly how many other women there were in her class, indicating an ongoing awareness of their position as a very small minority.

Electrical Engineering was also a large class with a low female participation, but the highest ethnic diversity of the sub-disciplines. In this class both male and female students perceived a complete lack of class spirit or bonding. The family-like class groupings spoken of by students in other disciplines had a different perspective in this context:

*I think in my class, it was divided more according to the race, but within the race it is like one big group, like one big family* *Mei, 4th year student E&E 1996*

*Our class is very segregated very groupy – like Hong Kong group, or the Malaysian group – mainly yeah you talk to each other when you need help with assignments but socially – not that much* *Amy, 4th year student E&E 1996*

*From what I see kiwis always hang around with kiwis and Chinese stick together in their groups. I tried mixing with Kiwis but feel like I wasn't welcome.*
*Questionnaire F2, 1996*

For students who did not fit into the "Chinese" or the "Kiwi" group, the potential existed for isolation, and I observed some students who appeared to have great difficulty in finding friendship groups:

*Don't have many chances to know my fellow students* *Questionnaire F10 (1997)*

*… they don't have to come out of their group to get help from others whereas I think I was sort of in between - there was not a big enough Indian group and I am not sure if I would have stuck to an Indian group if there was…* *Geetha, 4th year E&E,1996*

The majority of female students, however, appeared to quickly find a group of friends in second year with whom they associated closely throughout the following three years:

*…apart from the quantity of the work it wasn't a big problem because I had Sarah and Miriam and we would sit together and work…* *Heather, 4th year student E&E 1996*

My observation was that many of these friendships were task oriented and motivated by the need for academic support, and, in some cases, were recognised by the students as not likely to lead to lasting friendships:

*…the women friends I made at engineering school … we didn't have a hell of a lot in common really and the friendships have died. Circumstantial rather than really bounded in genuine friendship. If there were more women I would have made friends*

*with the ones with more equal academic abilities, but I didn't have those sorts of choices* *Melanie, new graduate E&E 1997*

Staff student relationships were perceived as having more formality in this discipline:

*There is a definite 'barrier' between the staff and students in our department. I have never seen what I would call 'easy' relationships between staff and students in our department* *Helen, new graduate E&E 1997*

There appeared to be a sense of caution in staff-student relationships, particularly cross-gender ("*like he is always careful to keep the door open if a female student come in*") or cross-race ("*overly polite so as not to give offence*"). I concluded also that age and power were strong deterrents for Asian students and staff compared to the typical "Kiwi" egalitarianism evident in some other departments. The only student who spoke of a relationship with their fourth year project supervisor in first name terms was a NZ European male student with a relatively young NZ European supervisor. The use of the titles Dr and Professor in informal conversation was the norm.

As mentioned in section 6.2.2, the spirit of co-operation and healthy competition within the class group, spoken of so commonly by students of other disciplines was not evident for the Electrical students interviewed from the class of 1996. Competition amongst Electrical students often appeared to be at a higher level than in other disciplines, but the class of 1996 was recognised as being competitive to an unhealthy level.

*The class of 96 was an unhealthily competitive class, even to point of sabotage of projects.* *Jstaff1, Jan 1998*

*I think in my class I can feel some competition between the class mates, it is not that easy to get help from them …Sometimes if I give you help you will be better than me… I actually had some friends who are fighting each other so hard that they hated each other* *Erica, 4th year student E&E 1996*

*E&E students don't support each other – E&Es often don't want to let their ideas out, course too competitive, often left floundering* *Questionnaire M3, 1997*

### 8.3.5 Homogeneity

I wrote in section 7.2.7 about the relative ease of the development of shared beliefs and assumptions if a group was homogeneous in background and experience. In the context of engineering education, if female participation was linked, as I have suggested, to perceptions of personal interest and "fit" with a sub-discipline, then I considered it important to examine homogeneity and diversity at both staff and student level.

Civil and Mechanical Engineering had the highest proportions of students from a NZ European background and, although it varied from year to year, male, "Kiwi" students were dominant numerically and socially. Civil Engineering staff were almost entirely "white", and long serving, with the largest proportion of professional rather than academic trained staff (i.e. without PhDs but with extensive industry experience). Mechanical Engineering staff were more ethnically diverse, with more than half who had done their graduate training outside New Zealand predominantly in Europe and the United Kingdom. All had PhDs and their background was more often in research rather than industry. A range of masculinities was manifested within the Mechanical staff. The group had a range of cultural and sporting interests, were younger and in my view less traditional and conservative than their Civil counterparts. I have already commented on the diversity, in terms of age, ethnicity and educational background of the staff in Engineering Science and this was reflected also in an increasingly diverse student body (although in 1996 the students were predominantly NZ European).

At the outset of my study one feature of Electrical Engineering which contributed to a stable subculture amidst growing diversity, was the high proportion of staff who were former U of A students, with little exposure to other universities or professional experience. At the student level, however, the Electrical Engineering department was increasingly the most ethnically diverse of all the disciplines, with over half the students of Asian, predominantly Chinese, ethnic background, having English as their second language. The most visible effect was a clustering by race, with groups able to converse in their own language and little need for some of these students to move into more integrated groups. At a student level it was unlikely that assumptions about homogeneity of personal values and behavioural norms could be made. The perception of staff and students from outside the department was that "*they are dominated by foreigners both in terms of staff and students*" (Sstaff2).

A much higher than normal female participation in this discipline occurred in the 1996 graduating class which had 22 females in a class of 99. Of these 22 women, three identified themselves as European, one Iranian, two Indian and 17 Chinese. It might be thought that female students would have had a strong presence in this class, but the opposite appeared to be the case, and none of the students or staff interviewed were able to come close to a correct estimate of this participation. I referred earlier (ref 6.3.3.2) to the ethnocentricity of the identical comment "*I can only think of three women in my class*" made by both male European Electrical students interviewed.

### 8.3.6 Relationship to Environment

Another one of Cobbin's (1995) generalisations had been that female participation was higher in those fields of study with higher status. In my study, I have earlier linked high status with high mathematical content at discipline level. On this basis Cobbin's generalisation did not match the statistics quoted in Table 8.1, except for Engineering Science which did have a high mathematical content, but also had a relatively high status reflected in demand for places, entry level, and international research profile.

Application data over several years had provided indications that some applicants appeared to link course desirability or status with entry criteria. Both male and female students were choosing courses such as Electrical Engineering (which had the highest entry level for engineering in the mid 1990s), and Computer Systems Engineering (similarly high in the late 1990s), as their second choice behind Medicine. Status appeared also to be implied by demand for the degree, reflecting perceptions of better employment. Both Electrical and Computer Systems were perceived as leading to lucrative employment in leading edge technology. In these disciplines however high status was not linked to high female participation, in fact the opposite appeared to be true.

A more appropriate linking of high status to high female participation appeared to apply to choice of institution than to sub-discipline. Cobbin's (1995) study had shown that participation was higher at the established universities compared with newer institutions where comparable courses were available. The combination of status of sub-discipline and institution was reflected locally in the considerably higher proportion of women in Electrical Engineering at the U of A (averaging 10-16%) relative to other tertiary institutions (averaging 5-8%), newer to university status, in the same region (see Appendix 2). Data provided in Appendix 1 for Civil Engineering in Queensland institutions for 2000 demonstrate this same trend.

Another contradiction to this generalisation, applied on a sub-disciplinary level, was Chemical and Materials Engineering, which had one of the lowest levels of demand, and did not appear to have “status” in terms of entry criteria, high level mathematics or high employment demand yet persistently had one of the highest female participation rates.

## 8.4 Summary

In this chapter I have used the framework of cultural dimensions that I had developed in Chapter 7 to explore previous explanations of variation in female participation and to compare and contrast values, norms and assumptions in the sub-disciplines. It was apparent to me that no one factor explained the persistence of sub-disciplinary participation rates. Rather, it was the combination of several factors and I summarise here the features I have found to highlight those combinations.

**Chemical and Materials Engineering**

- Knowledge providing tangible connections to real life – connected knowing;
- Seen as less focused on “hard” mathematics;
- Conservative NZ masculinity but bland rather than “blokey”;
- Low status in terms of entry level and demand;
- Female participation consistently >30% over many years;
- Small cohesive classes with close co-operation.

**Civil Engineering**

- Knowledge providing visible and tangible connections to real life – connected knowing;
- Seen as less focused on “hard” mathematics;
- Relatively high proportion of courses on environment and management;
- Conservative, oldest discipline bound by safety standards and regulations;
- Image as “blokey”, a traditional NZ masculinity;

- Low status in terms of entry level and demand;
- Female participation consistently around 20% – “comfort zone”;
- Female participants strong, confident with well-developed sense of social and environmental justice;
- Large classes predominantly European male but providing supportive niches for female students.

**Electrical and Electronic Engineering**

- Perception of difference from other engineering disciplines – them and us;
- High level of mathematics, symbolic languages and abstraction – separate knowing;
- High status in terms of entry standard and demand;
- Masculinity linked to obsession with technology and computers;
- Large class with competitive rather than co-operative culture;
- Numerical dominance of English second-language students;
- Female students spoke of survival rather than passion or enthusiasm for the discipline;
- Academic survival for female students linked to small supportive groups;
- Female students perceived as lacking in technical ability and competence.

**Engineering Science**

- High achieving, very focussed, innovative mathematical problem solvers;
- High order mathematics used in computer simulations of contexts ranging from biomedical, fluid dynamics (yacht design) to environmental – interdisciplinary;
- Staff relatively young, few with industrial or professional experience, often non-engineering background;
- Small cohesive, co-operative classes with strong sense of identity;
- Relatively high status entry level, and demand;
- Female participation valued – variable but usually over 20% – “comfort zone”;
- Masculinity a norm but perception of gender inclusion in language and behaviours.

**Mechanical Engineering**

- Masculine norms – "blokey", NZ masculinity at student level, staff more diverse;
- Essence of this discipline lay in Design – creative, innovative use of knowledge;
- Practical, "can do" attitude valued;
- Male students excelled in Design;
- Real life applications – but often outside female experience;
- Varied levels of mathematical content in courses;
- Large classes but co-operative atmosphere;
- Supportive niches for female students linked to similar ethnic, educational and socio-economic backgrounds;
- Female students confident and achieving academic potential.

In the preceding section I have identified that quite distinct hegemonic masculinities, using Connell's (1995) definition, were evident in the traditional New Zealand male model of masculinity found in Civil and Mechanical Engineering, and the technological obsession of Electrical Engineering. By contrast, the sub-disciplines of both Chemical Engineering and Engineering Science evidenced "softer", less "macho", but still recognisably masculine, cultural norms, without any one form of masculinity appearing to be dominant.

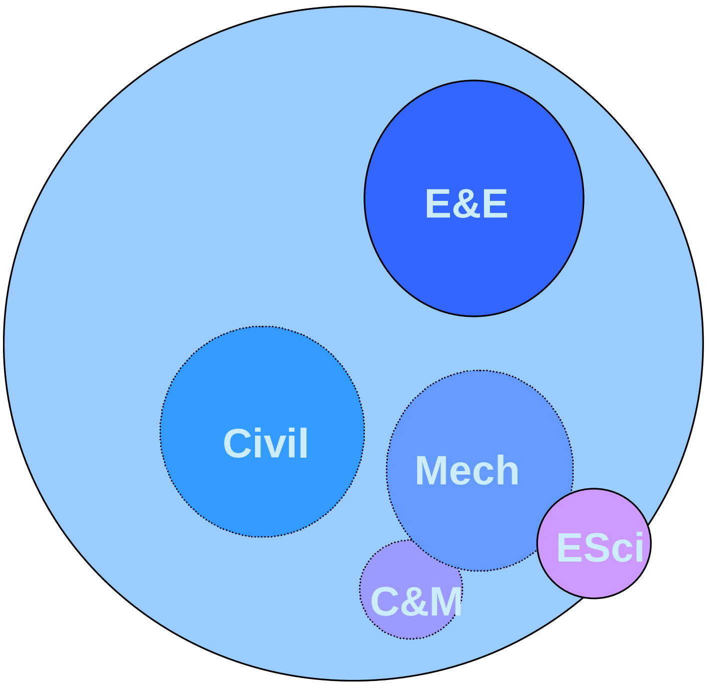


Figure 8.1 A symbolic representation of the masculinities of the Engineering Sub-disciplines

In Figure 8.1 I have used the traditional imagery of “blue for a boy and pink for a girl” to symbolise these masculinities. Shades of blue indicate the different masculinities and purple (pink combined with blue) to suggest the more gender inclusive nature of Chemical and Materials Engineering and Engineering Science. The positioning of Engineering Science in this diagram reflects the strong interdisciplinary links it has formed outside engineering. Despite courses taught in common with other engineering disciplines such as Mechanical Engineering and its professional engineering accreditation, this sub-discipline was perceived as located on the borderline of a “true” engineering discipline.

The level of integration of female students into these various sub-disciplines appeared to be linked to the extent they, as women and as engineers, needed, and were prepared, to identify with these masculinities. This integration was both academic, requiring adaptation to the prevailing way of thinking and doing within the sub-discipline, and social, requiring the support of task-oriented friendships. Even within the most masculine of disciplines, a supportive niche allowed the fulfilment of their academic and personal potential. Cobbin’s (1995) suggestion that women entered engineering leaving the traditions and culture intact, was largely confirmed in my study. The comfort and enjoyment of their educational experience reported by the majority of female students implied that adaptation and integration was accomplished with relative ease, but only in Engineering Science did the culture appear to have “opened up” to value and include women.

My findings in this chapter have reinforced research (Byrne, 1993; Cobbin, 1995) which posited that female students are attracted to people-oriented, socially-relevant engineering disciplines. I have linked this attraction to a preference for “connected” knowing, and lack of preference for the more “object-oriented” disciplines such as Mechanical and Electrical Engineering.

My findings also evidenced, contrary to earlier statements, also from Byrne and Cobbin, that advanced mathematics and computing were not always a deterrent. The increasingly high participation of females in Engineering Science provided a particularly compelling illustration in this regard. This increased participation occurred after 1996, when the timing of sub-discipline choice shifted to the end of the common first year. It appeared to be influenced by increased knowledge of content and approach of the sub-discipline gained during their first year, but was also attributed to the role modelling of personable, extrovert staff with a passion for their discipline, and to explicit affirmative action from the department to acknowledge a valuing of diversity. I saw this as confirming that perceptions of social integration could over-ride any notion that advanced mathematics and computing were in themselves deterrents to female participation.

In this chapter I have moved from the integrated cultural perspective of Chapter 7 to view sub-disciplines as subcultures within the over-arching culture of engineering education, with the specific aim of illuminating how subcultural differences impact on the participation of women. In considering the interaction of gender with those subcultures, in answer to my third research question, I have focused on the identification of gendered beliefs and assumptions. In my final chapter I will examine how gendered identities are formed and maintained within the masculine culture of engineering education, and the implications of the findings of my study for the participation of women.

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# Chapter 9

# Conclusion

## 9.1 Purpose and outline of this chapter

The purpose of this final chapter is to present a summary of my whole study and a synthesis of its outcomes. I will also discuss the significance of my findings for future research and strategising for change.

I begin with a brief overview of my study. I follow this with a review of my findings, my analysis and definition of the gendered culture and subcultures of engineering education. I then examine the formation and maintenance of gendered identities, as evidenced in my study, within the masculine norms of the culture of engineering education. I continue with a discussion of the implications of my findings for the participation of women at my case study institution. After a consideration of the theoretical and practical significance of my study, I then present a model for cultural change in engineering education. I conclude by distilling from my study some recommendations for future research and strategies that hold potential to enhance women's participation and success within engineering education.

## 9.2 Overview of my study

The primary problem explored in my study was the continued under-representation of women in engineering education, despite more than twenty years of international initiatives. I focused on the culture of engineering education, a culture which has been characterised internationally as reflecting masculine attitudes, values and norms of behaviour, thereby reinforcing the under-representation of women. My goal was to analyse and define this culture and the associated processes of enculturation, because its effects are far-reaching; for females, for males and ultimately for the engineering profession and the community as a whole.

In Chapters 1 and 2 I referenced a substantial body of research, ranging over engineering education, culture, gender and women's participation in science and engineering. Drawing on this literature, and over a decade of experience with affirmative action strategies, I highlighted limitations in practice and theorising which indicated to me a need to move beyond the “current” in the provision of more productive theoretical bases for action. These limitations included:

- perceptions that growth based on current initiatives had plateaued,
- the lack of a clear definition of the concept of culture in the context of engineering education,
- the need to build on theorising from previous research on the interaction of gender with the culture of engineering education,
- limited research into the processes of enculturation, and,
- the almost complete lack of research into the existence and nature of subcultures within engineering education.

After formulating research questions to address these issues, I conducted an interpretive (theory building) case study using primarily ethnographic methods of data collection. Through this research design, and my subsequent methods of analysis, (as illustrated in the findings which I have reported in earlier chapters) I was able to surface the shared meanings, tacit knowledge and lived experience of the members of the culture. I now review my findings in answer to my research questions.

## 9.3 Review of Findings

My first research question:

- What are the dimensions/elements of the culture of engineering education in the case study institution and how do they interact with gender?

arose from my recognition that, despite calls for change in the culture of engineering education, a definitive framework for culture in this context did not exist. As described in Chapter 3, I developed a model, based on Schein’s (1985) theoretical framework that guided my analysis at three levels. From the detail of the first level, the observable and tangible manifestations of the culture (grouped as Artefacts, Practices and Behaviours), described in Chapters 4, 5 and 6, I induced shared values and cultural norms as the second level of analysis. In Chapter 7, distilled from these values and norms, I presented the third level in the form of seven cultural dimensions containing shared beliefs and assumptions. I viewed these as the essence of the engineering education culture.

In answer to my second research question:

- How is the culture of engineering education learned in the case study institution and how does gender interact with this learning process?

I also synthesised, from my findings, the explicit processes of enculturation that appeared to shape students, especially women students, as they learned what it meant to be an engineer. My findings highlighted the importance of the first level of culture in the enculturation of students. Later, in section 9.6, I comment further on the importance of the Artefacts, Behaviours and Practices, the observable, tangible manifestations of the culture, when I consider strategies for cultural change.

The second part of my first and second research questions related to the interaction of the culture with gender. Throughout my findings in Chapters 4, 5 and 6 I wove examples of gendered interactions at the level of Artefacts, Behaviours and Practices, and identified gendered values and cultural norms, whilst interpreting from my own observations and the voices of the students and staff their understandings of the formation and maintenance of gendered identities. In Chapter 7 I examined each dimension of the culture, looking for gendered features. My findings confirmed and reinforced the masculinity of the basic beliefs and assumptions, at the core of the disciplinary culture, about what knowledge is valued, how it should be transmitted and the expected attributes for an engineer. For me, this masculinity was not unexpected. Indeed, given the volume of literature quoted in Chapter 2, combined with my own experience, it was almost a cliché to say that engineering has a masculine culture. However, the pervasiveness of this gendering in day-to-day practices, right down to the level of apparently unconscious assumptions, was revealed and emphasised in my study. Two themes emerged in my study from these masculine values and norms. Firstly, masculine values and norms were constructed in opposition to perceptions of “feminine”, and secondly, the dominant values and norms in engineering education resonated strongly with those of the white (or NZ

European) male.

One finding of my study was a strong sense of identity as engineers for both staff and students, which transcended sub-disciplinary boundaries. This strong sense of identity is probably responsible for the prevalence, on which I commented in Chapter 2, of perceptions in the literature of the culture of engineering education as homogeneous. Contained within the shared beliefs and assumptions of this overarching culture, however, was also a strong sense of sub-disciplinary cultures. My third research question:

- Viewing sub-disciplines as subcultures within the culture of engineering education in the case study institution, how do these subcultures interact with gender?

arose from the lack of research into the relationship between discipline specific subcultures and women's participation.

Persistent differences in women's participation and the wide variety of experiences and outcomes emerging from my data suggested that sub-disciplinary cultures could provide, not only examples of cultural features which were barriers to women's higher participation, but also examples of cultures which had "opened up" to include women. My findings on this research question, presented in Chapter 8, suggested that the differential participation by women in the sub-disciplines was a response to complex and sometimes apparently contradictory driving forces. Amidst the overall masculinity that I identified for engineering as a whole at academic and behavioural levels, I found that the sub-disciplines manifested different forms of masculinity. I comment further on the implications of the sub-disciplinary cultures in section 9.5.

As identified in Chapter 1, and elaborated in Chapter 2, I saw the crux of the "problem" of women's under-representation in engineering education lying in the implicit contradiction of seeking to encourage the participation of women (the feminine) within the masculine (not feminine) culture. In Chapter 2 I identified that, alongside the gendering of values and norms which led to the naming of a culture as gendered, in this case masculine, it was also necessary to explore the ways males and females construct appropriate gendered identities within a specific culture. Throughout Chapters 4, 5 and 6 I presented evidence of women and men's experiences within this "masculine" culture.

The contradiction alluded to above, and its inherent duality, are discussed in the next section where I have examined how gendered identities, which I have named "doing man" and "doing woman" interact with the masculine norms of "doing engineer".

## 9.4 Doing Gender – Doing Engineer

### 9.4.1 Doing Man – Doing Engineer

The masculine behaviours, practices and values which I have identified as cultural norms in the culture of engineering education implied that, for male students and staff, there was no ambiguity or contradiction in the dual roles of "doing man" and "doing engineer". For male students and staff, their maleness, or masculinity, was reinforced rather than threatened by their role as engineers. To be male was the norm.

In making this statement, I am not suggesting that all men can be considered as a homogeneous group. I acknowledge that a wide variety of behaviours and attributes have been identified (Connell, 1995; Dunlop, 1991), over time and in different cultures, as "masculine", and I identified several of these in this study. However, a common feature for all of the men observed in this study, both students and staff, was their denigration of things "soft" and implicitly "feminine" and therefore not masculine. This was evident, for example, in language style and the teasing put-down humour referred to in Chapters 4 and 6, which reinforced that identity and a sense of belonging as an engineer were closely linked to a particular male norm, or form of hegemonic masculinity. In Connell's (1995) terms this is that form of masculinity which "claims and sustains a leading position in social life" (p.77). In the context of this study, the hegemonic masculinity appeared to be that of the NZ European or Pakeha. In my case study institution the qualities and attributes identified by Phillips (1996) in his model of New Zealand masculinity were dominant and promoted as the cultural norm.

Connell (1995) proposed that such a hegemony was likely only if links existed between cultural ideals and institutional power. Within my case study institution, power, and the potential to dominate the values and assumptions, rested with senior academic staff, the majority of whom I identified as long serving and/or educated within the New Zealand education system. My observations and data confirm that they condoned or affirmed behaviours and practices which matched their personal beliefs and values.

Student power, at the time of the study, lay in the hands of the AUES (the engineering student society). As evidenced by my findings in Ch 4, 5 and 6, the AUES portrayed in publications, orientation events, and through its social activities, that a "real engineer" was synonymous with a "good Kiwi bloke". They represented the most visible masculinity within the student population, put forward as the cultural ideal. I saw the AUES as emphasising not only one form of masculinity, as distinct from femininity, but also implying a superiority to other masculinities. Because so few Asian students participated in the AUES, the predominantly NZ-European or NZ-born students appeared to be using these behaviours to emphasise not only their masculinity but also their separateness from other ethnicities. From the evidence presented in Chapters 4 and 5 of the ever-decreasing proportion of the student body that the AUES represented, I saw this positioning as resembling an endangered species desperately trying to retain and hold onto its dominant position.

### 9.4.2 Doing Woman – Doing Engineer

The masculine values and cultural norms that I have identified did not always resonate with the women students. Regardless of how accepted the women felt within that culture, or how desired their participation was espoused to be, my evidence showed that their acceptance as valid engineering students required the simultaneous construction and maintenance of their engineering identities "doing engineer" and their gendered identities "doing woman". The maintenance of this dual identity was an ongoing task. Julie's comment, reported earlier in section 6.5, that "*when I'm working in an engineering context I take on an whole different persona… I'm still female but I found the attitude I present helps others to take me seriously as an engineer*" (Julie, feedback 1996) embodied for me this sense of dual identity.

Using Byrne's (1993) scale, referred to in Chapter 8, being a female student in my case study institution was "untypical but sex normal", which appeared to imply difference rather than abnormality or exceptionality. In contrast, the low numbers of female staff members positioned them at the level of both abnormal and exceptional and as Byrne suggested "they do not count as in any way representative or as transferable models" (p.13).

Despite my findings that the culture was masculine and that, during enculturation, women (the feminine) adapted to (masculine) ways of knowing, behaving and relating, the students rarely acknowledged this adaptation as problematic. My data suggested that, in my case study institution, female students perceived themselves as able to operate and be accepted comfortably as individuals and students, with different personalities, strengths and weaknesses. In this sense, a diverse range of behaviours was evident for female students. These ranged from the "tomboys" wearing jeans, with hands in pockets, a striding walk, and a "*give as good as I get*", "*drink the boys under the table*" attitude, to those who wore miniskirts and platform soled shoes, and displayed submissive body language.

A strong theme running throughout my data (discussed in Chapters 6 and 7) was that it was OK to be a woman in engineering, but a woman engineer was likely to be different from other women. This different-ness had both positive and negative aspects depending on your perspective. There was a sense of superiority to other females amongst those who saw themselves as logical, mathematical, stronger, more independent, and less interested in "*girlie*" activities. There was also, however, an implicit understanding amongst both male and female students that, by doing engineering (a "hard" discipline), engineering women were likely to be less womanly than other women, not as "soft" – possibly not as feminine. This "different-ness" to other women appeared to be a source of tension for some of the students as they sought to address their dual role. Whether this different-ness arose from natural attributes or by training and socialisation was difficult for me to determine. Arguably, it but was probably a mixture of both.

For the women in my study, an initial level of self confidence in taking a degree that was "untypical" (Byrne, 1993) for their sex was followed over the years by a process of identity development. My data suggested that, as students went through their four years of study, the formation of a gendered identity that functioned in the engineering environment was a process of trial and error, as they monitored their own and others' conduct with respect to its gender implications. I have provided evidence of changes in dress and body language as confidence fluctuated, students finding appropriate boundaries for heterosexual relationships, and, for most, growth in confident, more assertive communication skills. They were not knowingly trying to be "like a man". Rather, they were learning to fit in and be accepted as engineering students, and some, if not all, recognised that this often entailed reinforcing qualities and behaviours which might traditionally have been identified as masculine.

The hegemonic masculinity in my case study, as my evidence showed, was negotiated by most women students with relative ease. Masculinity and being an engineer, were so inextricably linked that to question the former was to question being a "real" engineer. As observed also by earlier researchers (Copeland, 1995; Henwood, 1998, Stonyer, 1996) I found that female students typically avoided reflecting on issues of gendered identity. This is not surprising, given my evidence that to query a lecturer's sexist jokes, as Briar did ( 6.4.4) or formally complain about another student's behaviour (Mei in 6.3.3.2) took energy and time away from studies, and also risked marginalisation by classmates. This sense of avoidance of a difficult or potentially uncomfortable issue appears implicit in Chloe's comment, mentioned earlier in section 6.5: "*If I don't think about what it means to be a woman in this environment, then I can just be an engineer – one of the guys*" (Chloe, 1996).

The WEN T-shirts (section 4.6.1) evidenced the pride some women students felt in being both women and engineers. Yet, femininity, or being a woman, was often linked by the students either to sexuality (in instances such as dressing up for the Ball and deliberate flirting) or with weakness and "lack" (such as crying in the toilets and needing more help). The inherent duality contained in these conceptions of femininity, clearly constructed as "not masculine", also appeared to imply "not engineer".

There were two other areas of potential conflict between the women's identities as women and as engineering students. The first lay in the perception that female students received help from the predominantly male staff more easily than their male peers (section 6.3.2). Difference and deficit gender models were implicit in this perception. The second was the vulnerability for female students in heterosexual relationships, discussed in section 6.3.3.2. My data suggested that suppressing overt sexuality (or restricting romantic relationships to non engineering students) appeared to be necessary for acceptance as a credible, serious engineering student.

In summary, I concluded that an ongoing and pervasive dilemma existed for women students – a dilemma which was rarely confronted or articulated. How could they negotiate difference from men and yet difference from other women? I argue, on the basis of the evidence I have provided, that studying engineering reinforced a particular form of "doing woman", where control of emotions, independence, technical competence, strength, logic and decisiveness – all qualities normally identified with masculinity – were part of that gendered identity. Women engineering students appeared to have selectively constructed a conception of femininity in which the feminine qualities of valuing connection and relationships, cooperation and caring were still part of what it meant to be a woman, but any qualities seen as synonymous with weakness were not. For these women it therefore seemed that a range of masculine and feminine attributes co-existed in their identities as women. For male engineering students, no such ambiguity existed. A variety of manifestations of masculinity appeared to be acceptable, but any hint of femininity was abhorrent.

## 9.5 Implications for the Participation of Women

Encouraging participation by women (the feminine) in a discipline that is so conclusively masculine (i.e. not feminine) has implications for both the women themselves, and the discipline of engineering. I have based this study, and my work over many years on the assumption that women's participation in engineering was desirable for the profession, the community and not least, for the women themselves. Holding that assumption in mind, my findings support Cronin & Roger's (1999) statement that both sides of the duality, or conflict as they expressed it, between the feminine gender identity and the masculine culture must be addressed for increased participation. Expanded understandings of what it means to be a woman must go parallel with expanded understandings of the culture of engineering education and its potential for change.

One of the reasons that I chose the U of A as a site for this case study was my perception that the relatively high levels of recruitment, retention and academic outcomes of women, combined with the national culture and sub-disciplinary variations, might provide insights into a culture which had to some extent "opened up" to include women. Despite identifying the culture as masculine, my findings suggest three possibilities which have contributed to the growth in women's participation and the relative ease with which the women students appear to negotiate the culture.

Firstly, in a country with a tradition of strong women's voices and in which all the top political positions are currently held by women, the traditional gender roles in New Zealand society (as described by James (1989) and Phillips (1996)) appear to have become more flexible in the late 1990s. Current New Zealand models of masculinity appear to be associated with a national engineering education culture in which gender roles are less sharply defined than in the past.

Secondly, my data evidenced the common perception that gender differences were increasingly blurred by wide ethnic diversity and consequent variation of acceptable masculinities and femininities within this context. Where more than one form of masculinity was manifested, I suggest there was space for women to construct alternate femininities.

The third feature I identified was that initial affirmative action interventions had raised participation levels by women past the "token" level to a "comfort zone" where sufficient women were present for them to be "untypical but sex normal" (Byrne, 1993). Women were no longer viewed as pioneers or exceptional, and, particularly in some of the sub-disciplines identified in Chapter 8, there were sufficient women in class groups for them to be viewed as individuals with different strengths and personalities, rather than perceived solely as women or "other" than the male norm.

I have identified (section 7.3) the masculinity implicit in many of the cultural norms and assumptions around the “engineering way of thinking, teaching and learning”. The curriculum explicitly included communication and management skills, and issues of social and environmental responsibility. The inclusion of these generic skills provided opportunity for reflection and connection, and allowed discourses other than the mathematically provable and scientific into engineering education. I suggest that, together with an emphasis on teaching and learning within real life, relevant contexts, these norms provided opportunities for women, as well as many men, to “connect” and “do engineering”.

My affirmative action role within my case study institution, with its involvement in recruitment events, preparation of publications, support of student networks, and pastoral care interactions, as discussed in previous chapters, was a factor in high female retention rates and positive personal and academic outcomes for the majority of women students. I also posit that the commitment by the School of Engineering to increasing the participation of women, exemplified by the support of the WISE position, combined with growing numbers of women students, had resulted in a weakening of some of the excessive social aspects of masculinity within the culture.

Academic aspects of the U of A culture were, however, left largely untouched by this increased participation of women. The changes made in curriculum and pedagogy, which I have identified as “female-friendly”, were made on the basis of “good practice” or “required by the profession”, without conscious thoughts of gender inclusion or alternative cognitive styles.

This study has therefore shown that the U of A School of Engineering culture had features that supported women’s participation, but the culture itself had only marginally “opened up” to include women. The high participation and retention of women appeared to be largely due to changing societal expectations and aspirations for women and affirmative action initiatives, rather than planned cultural change. My findings led me to the conclusion that the prevailing trend at my case study institution reinforced Cobbin’s (1995) view that motivated women entering engineering education accepted the culture, as is, and adapted to it. The relative ease of this adaptation and integration may have been responsible for high retention rates and perceptions of positive personal and academic outcomes for female students. It appeared, however, that the mere maintenance of current cultural values and norms would have little influence on increasing participation past the current plateau of 20%. Something more would be needed if further increase was to occur.

Some “opening up” or “softening” of the masculine nature of the culture appeared, in particular, to have happened at the sub-disciplinary level. In Engineering Science, for example, as I discussed in Chapter 8 the combination of academic and social cultural features which had resulted in a culture which appeared to value and include women, although I noted also the influence of key staff in maintaining this culture. In the other disciplines, even Chemical and Materials Engineering, the level of integration for female students, as women and as engineers, appeared to be linked to the extent they needed, and were prepared to, identify with masculine qualities seen as appropriate to the discipline. The importance of social integration and supportive friends to academic success and perceptions of self-efficacy was a strong feature of my findings, emphasised particularly by outcomes for women students in the sub-disciplines. Even within the two sub-disciplines which were the most “masculine”, albeit masculinity constructed in contrasting ways, the finding of a supportive niche appeared to result in the fulfilment of academic and personal potential for women. I argue, however, that the serendipitous nature of “finding a supportive niche” lent a fragility to perceptions of social integration in these disciplines. My examination of the sub-disciplines highlighted variation in the academic and social integration for female students, providing both extremely positive and negative outcomes, which were masked by discussion of engineering education as a whole.

In the previous section I have proposed that female students appeared to have constructed their own form of dual identity “the engineer who is a woman” which enabled them to be valued as women and as engineers. To be taken seriously as an engineer, they perceived the need to display qualities stereotypically associated in the local culture with masculinity without losing those feminine qualities which they deemed to be appropriate. The use of this concept of dual identity adds to the work of others who have proposed that women who are engineers have androgynous (Newton, 1987) or ambivalent (Newhouse-Maiden, 2002) qualities and attributes.

## 9.6 Implications for Future Research and Practice

My analysis and definition of the culture of engineering education, which I have identified throughout this study as implicated in the under-representation of women, was presented in Chapter 7. One aspect of the theoretical significance of my study lies in the accessibility of the model I have proposed for the cultural analysis of an academic discipline, in this case engineering education. Using this model I have exposed the likely source of observable Artefacts, Behaviours and Practices in the underlying values and norms, and at a deeper level in the shared beliefs and assumptions. The latter, I have argued, form the core or essence of the culture of engineering education at my case study institution.

I provided considerable detail in Chapters 4, 5 and 6 of a selection of these Artefacts, Practices and Behaviours in my case study institution to make explicit the processes by which they were formed and sustained as cultural norms from their sources in shared beliefs and assumptions. I then identified seven cultural dimensions around which these shared beliefs and assumptions have formed, as engineering educators and students sought to find their personal and collective answers to “issues of external adaptation and internal integration” (Schein, 1985).

Some features of the culture at my case study institution may have been unique, such as the tradition and valuing of integration between the sub-disciplines, and the sense of identity and isolation from the wider university. I do not suggest that these features are generalisable to all engineering institutions or sub-disciplines. However, many of the beliefs and assumptions, which I have identified in Chapter 7, appeared to be the source of practices and behaviours identified in Chapter 2 as common in engineering education.

The validity of my findings and evidence cited in this study was confirmed in feedback discussions with colleagues from my own and other engineering institutions. It is, however, my model (with its seven cultural dimensions that evolved from my findings) which I see as generalisable, rather than specific behaviours and practices. This model provides a theoretical framework around which other institutions can undertake cultural analyses. Each institution may well manifest the dimensions I have proposed in unique and characteristic ways. However, the strength of my model lies in its accessibility to engineering educators and its potential to demonstrate that culture does not lie in observable behaviours and practices but in the underlying shared beliefs and assumptions which sustain them. Identification and recognition of these underlying assumptions, unconsciously held and taken for granted, and the enculturation processes by which they are constantly reinforced and taught to students, provides a clearer understanding of the enduring nature of many of the behaviours and practices referred to in the literature.

In presenting my findings I am reminded of the quotation I provided at the beginning of Chapter 3:

> *What we find as researchers depends on how deeply we cast our nets, how narrow the mesh is and what ponds we choose to fish in.*
>
> *Allison (1974) cited in Trowler, 1998, p.147*

In the process of this investigation, several issues arose which were outside the scope of my specific research questions but which cry out for further research and analysis. I see the need to examine and deconstruct specific aspects or dimensions of the culture, in even greater depth as part of the larger whole. Each institution or discipline using my model will inevitably bring a different perspective. Particular issues which arose for me as needing further research were:

- The construction of professional identities within post graduate study and research groups.

Ongoing discussions with my interviewees who had proceeded to postgraduate study revealed the reinforcement and embedding of cultural values and norms at post graduate level, some of which caused a social and academic discomfort for female students not experienced at undergraduate level. If academics were responsible, as identified in this study, as the prime influence on the transmission of cultural beliefs and assumptions, then in-depth understandings were needed of the cultural dynamics within research groups, where potential academics were trained.

- The implications for academic women staff in how cultural values and norms were enacted in areas such as staff relationships, promotions, decision making.

This thesis, focussing on the disciplinary culture, did not explore the full implications for women staff of these issues, but they are of vital importance if women are to take their place as valued contributors to engineering education. My change in status, post data collection, to that of an academic staff member (now a true ‘insider’) revealed concerns about how teaching was evaluated, what was valued for promotion purposes and whose voices were valued in decision making.

The extension of my model and consequent findings relating to sub-disciplinary cultures is significant as a first step to filling a gap in current theorising and research. As mentioned earlier, my research has exposed inconsistencies in academic and social integration for women in the engineering sub-disciplines.

In particular, the persistent sub-disciplinary levels of participation appear to suggest a self-fulfilling prophecy, “disciplines with more women develop cultures that attract more women”. For me, these findings confirmed an on-going but unresolved dilemma. Where a cultural analysis such as mine revealed a sub-disciplinary culture had developed which did not nurture and value women students, was it ethical to promote women’s participation unless, and until, explicit interventions were in place both for support and cultural change?

My data also appeared to echo the views of Stonyer, (1996, 2001) quoted in Chapter 2, that, as some sub-disciplines continue to increase in female participation, they may come to be viewed as “soft” engineering – feminine or, at least, not as masculine – with a consequent devaluing as not “real” engineering. This leads me to ask: If men continue to dominate those sub-disciplines with greater depth in the use of mathematics, a higher focus on design and the purely technical, will the perceived masculinity (and “hardness”) of these sub-disciplines perpetuate their positioning as “real” engineering? Disrupting the “hard”/“soft” (masculine/feminine) duality and its links with worth and status, in ways which respect and value equally the contributions of individual sub-disciplines, I see as an ongoing challenge.

Further research and analysis should, I argue, avoid consideration of engineering education as a homogeneous culture. Deconstruction of the dimensions of the sub-disciplinary cultures is a necessary precursor to disrupting the persistent under-representation of women in some sub-disciplines.

Moving on from the theoretical bases of the concept of the dynamic construction of gendered identities, and the concept of “dual identities”, I have encouraged the view that “doing woman” and “doing engineer” might not be mutually exclusive, despite my identification of engineering education as a masculine culture.

The theoretical model of the engineering education culture that I have provided can be of practical significance at strategic and operational levels in the implementation of desired cultural change. In the next section, I demonstrate the potential of my model in relation to planning cultural change.

### 9.6.1 Changing the Culture

I commented in Chapter 1 that my interest in the relationship between the culture of engineering education and women’s participation had been stimulated by the IEAust Review “Changing the Culture” (1996). I have shown in earlier sections that the culture of engineering education is founded upon and sustained by values and norms which are commonly identified as masculine. I have also argued that cultural change must be based on an awareness of the basic beliefs, values and assumptions held by both staff and students, and an understanding of how they combine with the construction of the discipline to implicitly guide actions.

I present Figure 9.1 to demonstrate how cultural change might be effected. In the terms of this model, I see sustained systemic cultural change supported by shifts at the deepest level of shared beliefs and assumptions, and up through values and cultural norms.

As shown in Figure 9.1 planned change might be initiated by strong and motivated leaders (at third level), able to articulate beliefs and assumptions, and the values and cultural norms which would manifest them (at second level). Vision would need to be coupled with the power to put in place changed artefacts and practices, at the first level, which would enhance the development of behaviours. These, once sustained, learned and shared by members of the culture, would initiate completion of the cycle by influencing cultural norms and ultimately the assumptions of the whole group. In the current world of higher education with its economic and resource constraints I acknowledge that this is an idealistic picture, and interventions to initiate cultural change are more likely to come from strategic planning at the level of espoused values.

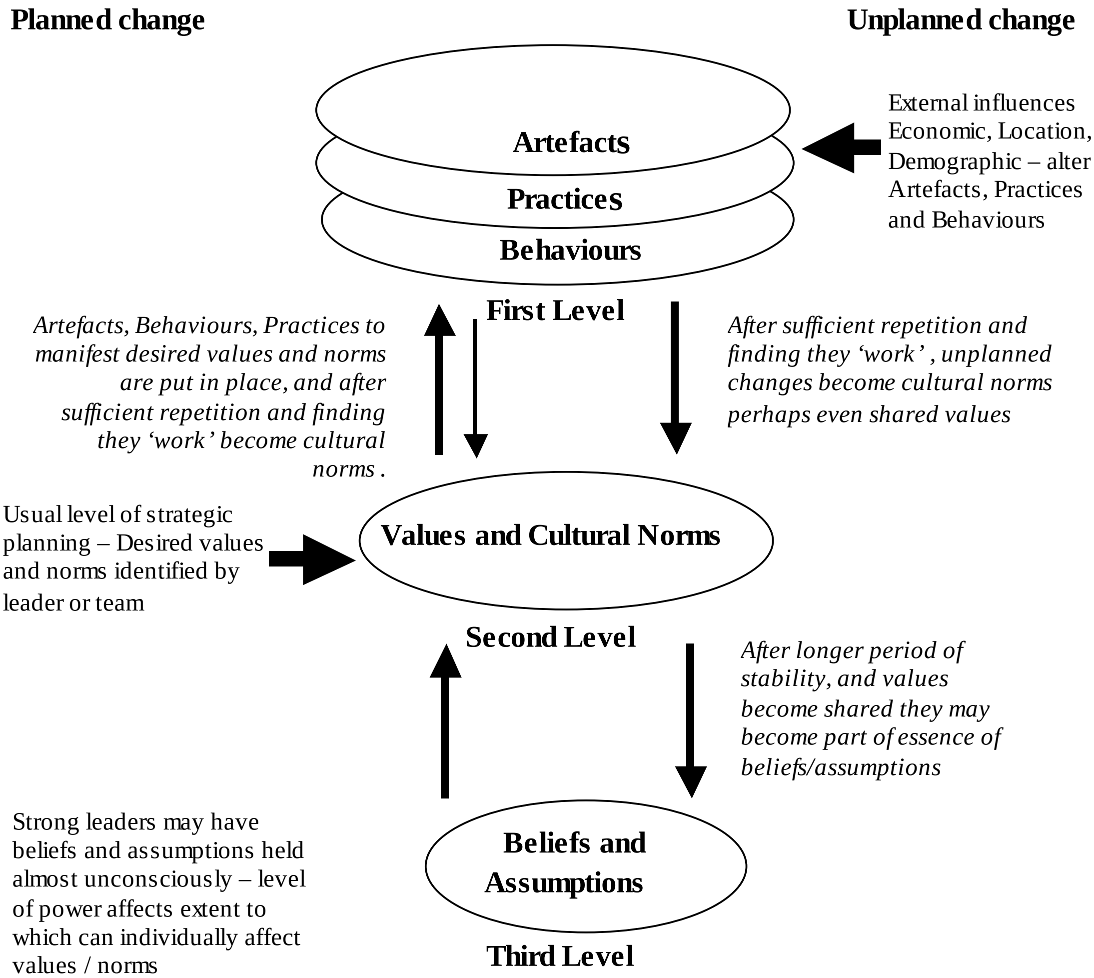


Figure 9.1 A model for cultural change in engineering education

I see the most important step in effecting change as manifesting those espoused values at an operational level. As I have demonstrated in answering my second research question, it is at the first level of behaviours and practices that newcomers initially learn what is valued in a culture, and unless these behaviours and practices reflect desired values and norms, sustained cultural change will not occur.

As I have discussed in Chapter 2, cultures are dynamic systems of meaning, and are responsive to changes in the world. Unplanned, rather than planned, change can come from external influences such as a change of location, changes in selection criteria, change in ethnic mix of students, increased tuition fees, and growth. These can all stimulate rapid changes in Artefacts, Practices and Behaviours. If these changes are sustained, without intervention, different cultural norms may emerge, which may or may not be in conflict with espoused values. After some time, there is the potential for some cultural features to become embedded at the third level of beliefs and assumptions. In my case study institution rapid growth in the student population near the end of my study was an example. This rapid growth appeared to be leading to fragmented locations and changing teaching practices, followed by the loss of intimate “family”/friendship, competition, an increase in instrumentalism and the potential for change in beliefs and assumptions about appropriate forms of relationships.

This change model is significant in a practical sense because it takes account of the established practice within academia of basing strategic planning on a foundation of theory and research. My model is accessible in theory and discourse to both engineering educators and advocates for women in engineering. Further development of the model is envisaged to provide measures, or performance indicators for each of the seven cultural dimensions to enable the model to be operationalised once researchers, practitioners and policy makers have conceptualised the issues and defined strategies for desired cultural change.

### 9.6.2 Strategising for Change

As I commented earlier in this chapter, the essence of strategising for change to a more inclusive culture lies in disrupting the inherent contradiction between the feminine gender identity and the current masculine culture.

I have shown that the culture of engineering education is not only gendered, but influenced by the culture of academia, the requirements of the professional engineering bodies, and the particular national and local community cultures. To find a “way through” this web of cultural influences I see the need to investigate ways of naming and analysing engineering education culture that will identify, and affirm, those behaviours and practices which reinforce inclusive core values and cultural norms. A shift is needed in the discourse from dualities tied to masculinity/femininity to using language and terminology that is less gender oriented. In Chapters 1 and 2, I identified the tendency of some previous research on female under-representation in engineering to cast women in a deficit role, aggregating them into one category, and viewing them as “other” or “exceptional” to the main stream of engineering. Because of the dualities so pervasive within our language and thinking, it is difficult to avoid reinforcing that sense of difference and/or deficit.

I argue that the naming of the culture as masculine (i.e. not feminine), whilst accurate, limits this discourse for two reasons. Firstly, it is difficult to envisage change emanating from the group (men) which I have identified as advantaged by the masculinity of the culture. Secondly, it reinforces the duality that must be disrupted if women (the feminine) are to be encouraged to participate in engineering education.

The use of terms such as “hard” with its implications of hard = masculine and soft = feminine (and therefore hard = not feminine) emphasise the gendered understandings in so much of our language. I propose it is more productive to speak of the culture as rigorous, and as valuing mathematics, analysis, design and open ended-problem solving. The difficulties in language which have, for so long, constructed thinking in terms of dualities must be confronted with imagination, coupled with integrity. Strategies such as the inclusion of material emphasising the social, political and environmental responsibilities of engineers, mentioned in calls for cultural change (IEAust, 1996) and in recommendations for gender inclusive curricula (Ayre, Nafalski & Priest, 1998; CuWaT, 1998; Moxham & Roberts, 1995), must be developed in an environment which does not construe this material as “soft” or marginalised from “real” engineering. It will be challenging to conceive of strategies which recognise trends that might be gender related, such as preferences for separate and connected knowing, without converting those trends into generalisable variables. Gender related trends should not imply that boundary crossing cannot occur.

The disciplinary culture of engineering education described in Chapter 7, with its emphasis on problem solving and the application of mathematics, science and technology to real life issues and situations, provides a unique and valuable contribution to higher education and the training of its students, and ultimately to society. Many of the enduring cultural features which I have described, such as the focus on the quantifiable and measurable, the “challenge and stretch” pedagogical paradigm, perceptions of heavy workload and the sense of a identity as engineers, have implications for the participation of women, but are not intrinsically inappropriate for women.

The challenge, as I see it, is twofold. The first challenge is to preserve pride and identity in a professional education while, at the same time, exposing behaviours and practices to critical reflection by staff and students. If a high proportion of coursework is valued because it provides opportunity for open-ended problem solving, and if “challenge and stretch” is a desired learning paradigm, then these values must be made explicit. If both documentation and practice reinforced “challenge and stretch” as a learning outcome, then perceptions could be shifted from those of “sink or swim”. All students, both female and male, would then appreciate the source of practices. The second challenge is to maintain those features which are the strength of engineering education, but to widen the view to include and value ways of knowing and learning styles from outside the current disciplinary and gendered boundaries.

To meet these challenges I recommend the following strategies for staff to implement:

- Ask for, hear and act on the voices of engineers who are women or currently on the margins of the culture, without assumptions of homogeneity.

  A finding of my study was the perception that women in engineering were different to other women, and that they had constructed for themselves a feminine identity which included a selection of stereotypically masculine and stereotypically feminine qualities in parallel with a love and passion for engineering method and practice. In addressing the need for expanded understandings of what it means to be a woman within engineering, the voices of these women need to be heard. Generalisations about gendered ways of knowing, behaving and interacting need to be appropriately adapted for engineering education by research coming from within the discipline.

- Actively consider, and investigate, material already available on gender inclusive teaching and learning for examples of behaviours and practices which could manifest desired values.

- Provide time and space for reflection: Use qualitative action research processes to self-analyse pedagogy and assessment. Ask the questions: What do we value? How do we manifest that? How do our cultural norms match our values?

- Explicitly value interdisciplinary interaction – recognising and valuing alternate ways of knowing.

Two areas of further research emerged from my findings as likely to be productive for future strategic planning. The first was to extend understanding of the nature of the sub-disciplinary subcultures of engineering. Only by deconstructing these sub-disciplinary cultures can cultural features that either aid or hinder the participation and performance of women be recognised.

The second area I saw needing further research also arose from my investigation of the sub-disciplines. My awareness of ethnic diversity, with all its implications for culturally different understandings of femininity and masculinity, reinforced for me the danger in treating women and men as homogeneous groups. This was particularly illustrated by the low participation by NZ-European women in sub-disciplines such as Electrical Engineering, in contrast to the higher participation by women of Chinese or Indian ethnic backgrounds. In several countries, such as France and India, women-only Schools of Engineering exist. Research into the dual identity of "doing woman" and "doing engineer" in a range of these ethnic and national contexts has the potential to provide exemplars of alternate ways of "thinking and doing" within engineering education and the cultural mores that maintain them.

In strategising for change, I argue that the observable, tangible manifestations of the culture, named in this study as Artefacts, Practices and Behaviours, which provide the first point of contact, must consciously and explicitly be gender inclusive. For sustained and long term cultural change those Artefacts, Behaviours and Practices must be underpinned and built on values and cultural norms which include and accept a diversity of gendered identities.

## 9.7 In conclusion

I recognised at the outset of this study that long term change will come from a gradual accumulation of knowledge and experience, rather than from a single study. However, by providing an analysis of the culture of engineering education and the significant ways that gender interacts with that culture, my study has added a new voice to the discourse surrounding women's participation in engineering education.

My close contact, questioning and discussions with staff and students at the U of A School of Engineering throughout this investigation have provoked reflection, and new perspectives for all concerned. Culture has become part of our vocabulary, with a growing understanding of its significance in practice and planning. As I wrote in Chapter 1, there are no simple or complete answers to women's under-representation in engineering education, but:

*We shall not cease from exploration*
*And the end of all our exploring*
*Will be to arrive where we started*
*And know the place for the first time* *T.S.Eliot "Four Quartets"*

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# Appendices

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# APPENDIX 1

## Australian Statistics of Participation by Women in Engineering

### 1. Female Participation in Different fields of engineering

Table A1.1 Participation in different fields of engineering – all levels of study

| **Field of engineering** | **1989** | **1994** | **1999** |
|---|---|---|---|
| | | | |
| Chemical | 22.1% | 31.9% | 32.2% |
| Metallurgy/Minerals | 9.7% | 18.0% | 19.5% |
| Industrial | 10.8% | 15.3% | 14.1% |
| Surveying | 11.6% | 14.0% | 14.9% |
| Civil/Structural | 8.3% | 13.4% | 14.2% |
| Engineering, general | 12.2% | 13.2% | 13.5% |
| Aeronautical | 9.8% | 10.9% | 10.7% |
| Electrical/Electronic | 5.9% | 9.1% | 14.3% |
| Mechanical | 4.2% | 7.2% | 7.7% |
| Marine | 0% | 3.8% | 6.1% |
| **Total** | **8.9%** | **13.1%** | **14.8%** |

Source: Lewis, S., Harris, R., Cox, B. (2000) *Engineering a better workplace.* Canberra:Institution of Engineers, pp.9, Table 3.

### 2. Female participation across the field of Civil Engineering, in one state, illustrating the range of participation across different institutions.

Table A1.2 Female participation across the sub-discipline of Civil Engineering in Queensland for the year 2000.

| **Institution** | **% Female Participation** |
|---|---|
| Central Queensland University | 11% |
| Griffith University | 6% |
| James Cook University | 18% |
| Queensland University of Technology | 14% |
| The University of Queensland | 22% |
| University of Southern Queensland | 13% |

Source: DETYA*: Selected Higher Education Student Statistics* 1995-2000
Author Tatjana Lukic,17 September 2001

## 3. Female participation in Professional Engineering

Table A1.3 Membership of IEAust (April 2003)

| Membership type | Total | Female | % female |
|---|---|---|---|
| Chartered member | 29,442 | 552 | 2% |
| Member or Fellow | 33,834 | 891 | 3% |
| Graduate | 12,472 | 1,416 | 11% |

Source: Membership Manager, IEAust, (personal communication 2 April, 2003)

Employment data in Table A1.4 cited in Lewis, Harris and Cox (2000, p.10) have been taken from the Australian Bureau of Statistics and are based on the 1991 and 1996 Census survey to all households in Australia. Categories of employment are based on the Australian Standard for Classification of Occupations. The aggregate data shown in Table A1.4 illustrates the numbers of professional engineers and are listed separately from associates and technical classifications where there are higher numbers of women – although still less than 10% of all the codes.

Table A1.4 Total number of professional engineers by gender – 1991 and 1996.

| Year | Females | Males | % Females |
|---|---|---|---|
| 1991 | 3856 | 78175 | 4.7% |
| 1996 | 5844 | 78294 | 6.9% |

Source: Lewis, S., Harris, R., Cox, B. (2000) *Engineering a better workplace.* Canberra:Institution of Engineers, p.10.

# APPENDIX 2

## New Zealand Statistics

### 1. Secondary School - NZ University Entrance Bursary Examination

Table A2.1 Participation and Attainment in Selected Bursary Subjects by Sex, 1997

| Subject | Participation | | Attainment | |
|---|---|---|---|---|
| | Female | Male | Female | Male |
| Accounting | 13.4% | 15% | 38.3% | 46.5% |
| Biology | 37.5% | 26.7% | 40.9% | 40.1% |
| Chemistry | 20.7% | 26.2% | 50.2% | 52.3% |
| English | 63.1% | 45.3% | 44.3% | 32.5% |
| Maths with Calculus | 25.9% | 39.8% | 48.1% | 46.3% |
| Maths with Statistics | 40.6% | 50.4% | 40.6% | 44.6% |
| Physics | 14.7% | 32.8% | 55.7% | 52.5% |

Note: Participation rate is the percentage of male or female candidates who took a particular subject. Attainment rate is the percentage of male or female candidates who gained either a scholarship, grade A or B in a particular subject

Source: New Zealand Now :Women (1998, p. 62) Wellington,NZ: Statistics NZ

### 2. Participation in Tertiary Engineering degree programs

National data for formal engineering qualifications, with four year BE degree programs disaggregated from 3 year degrees and Diploma programs is not available. The following data was collected by the New Zealand Council of Engineering Deans in May 2002.

Table A2.2 Undergraduate students commencing BE or BE equivalent programs in 2002

| Name of Institution | Undergraduate Commencing Students | | | | | |
|---|---|---|---|---|---|---|
| | Total BE | NZ | NZPR | Overseas | % Female | % Maori |
| UNIVERSITY OF AUCKLAND All disciplines | 579 | 66.6% | 22.4% | 10.9% | 20.40% | 4.2% |
| AUCKLAND UNIVERSITY OF TECHNOLOGY (Mechanical and Electrical | 65 | 65% | 24.7% | 10.3% | <5% | 5-7% |

| | | | | | | |
|---|---|---|---|---|---|---|
| UNIVERSITY OF CANTERBURY All disciplines | 300 | 83.67% | 8.67% | 7.67% | 14.90% | n.a. |
| MANUKAU INST. OF TECHNOLOGY (Electronic Engineering) | 62 | 83.87% | | 16.13% | n.a. | n.a. |
| MASSEY UNIVERSITY BE (Computer Systems, Mechatronics, Software) | 185 | 84.32% | 3.78% | 8.11% | 8.90% | 5% |
| (BTech including Food technology) | 68 | 82.35% | 8.82% | 2.94% | 32.80% | 4.68% |
| UNITEC (Environmental Engineering) | 12 | 50% | 33% | 17% | 40% | 0% |
| UNIVERSITY OF WAIKATO (Electrical, Materials and Engineering Science) | 60 | 76.67% | 21.67% | 1.67% | 12% | 8% |

Notes:
Only University of Auckland and University of Canterbury offer a full range of BE programs.
Some data provided by institutions was estimated.
NZ refers to New Zealand citizens
NZPR refers to New Zealand permanent residents
Overseas refers to International fee paying students

## 3. Participation in Professional Engineering

Table A2.3 Membership of IPENZ (Institution of Professional Engineers New Zealand) 2002

| | Male | Female | Percentage |
|---|---|---|---|
| Professional members | 4250 | 123 | 2.81% |
| Graduate Members | 1351 | 238 | 15.0% |

Source: Membership secretary, IPENZ, March 2003.

Notes:
Graduate members are those who joined since completing a four year BE degree or higher qualification but have not undergone Competency Assessment to become full Members.

## 4. Human Resources in Science and Technology in New Zealand

Table A2.4 The number of scientists and engineers in 1996

| 1996 | Male | % | Female | % | Total | % of total |
|---|---|---|---|---|---|---|
| Natural scientists | 1,530 | 77.0 | 453 | 22.8 | 1,986 | 4.1 |
| Mathematicians Statisticians | 327 | 66.5 | 162 | 32.9 | 492 | 1.0 |
| Computing Professionals | 5,142 | 78.4 | 1,416 | 21.6 | 6,558 | 13.5 |
| Engineers | 20,613 | 93.0 | 1,542 | 7.0 | 22,173 | 45.7 |
| Life Science Professionals | 3,603 | 76.4 | 1,113 | 23.6 | 4,719 | 9.7 |
| Health Professionals (except Nursing) | 8,139 | 64.5 | 4,470 | 35.4 | 12,618 | 26.0 |
| Total | 39,354 | 81.1 | 9,156 | 18.9 | 48,546 | 100.0 |

Source: “Human Resources in Science and technology in New Zealand” (December, 1998)
http://www.morst.govt.na/pubs/hr/empirical.html

Notes:
This table used data taken from the 1996 Census using the OECD definition which categorises as scientists and engineers all those persons working as physical, mathematical and engineering science professionals, as well as life science and health professionals. Scientists and engineers form part of the professional group, which is major group 2 of the International Standard Classification of Occupations (ISCO).

# APPENDIX 3

**Final Year Student Survey**
**Distributed October1997**

Please answer as honestly and completely as you can - your opinion is important.

**Personal and Educational Background**

1. Engineering Discipline ..........................................................
2. Ethnic Origin .........……............................................
3. School Attended: Single Sex ☐ Co-ed ☐
4. If you came to University direct from school, was your final year at school

   Sixth Form ☐ Seventh Form ☐
5. Was Engineering your first choice of profession? Yes ☐ No ☐

   If not what other careers had you considered?

   ........................................................................................................................
6. Before entering the Engineering School did you know any engineers personally?

   Male ……….. Female …………..
7. Are any of your close family or friends engineers? Yes ☐ No ☐

   State Relationship .........................................................................................
8. What influence were any of these people on your choice to do engineering

   ………………………………………………………………………………………

   ………………………………………………………………………………………
9. At school level, how did you gather information about engineering?

   Careers Advisor ☐ University Liaison Officer ☐ University Open Day ☐

   Enginuity Day ☐ Other?.........................................................................
10. Why did you study Engineering rather than some other degree course?

    ………………………………………………………………………………………

    ………………………………………………………………………………………
11. Have you been happy with your decision to study engineering?

    ………………………………………………………………………………………

    ………………………………………………………………………………………
12. Who or what influenced your selection of the branch of engineering you pursued?

    ………………………………………………………………………………………

    ………………………………………………………………………………………

**Engineering School**

Please comment on how you personally experienced the Engineering School

13. The Lecturers

…………………………………………………………………………………………

…………………………………………………………………………………………

14. Your Fellow Students

…………………………………………………………………………………………

…………………………………………………………………………………………

15. The Course Work

…………………………………………………………………………………………

…………………………………………………………………………………………

16. Were there any courses that you particularly enjoyed and why do you think that was?

…………………………………………………………………………………………

…………………………………………………………………………………………

17. Were there any courses that you did not enjoy and why do you think that was?

…………………………………………………………………………………………

…………………………………………………………………………………………

18. Did you get involved with the social activities of the Engineering School?

| | | |
|---|---|---|
| Engineering Society | Yes ☐ | No ☐ |
| Class organised events | Yes ☐ | No ☐ |

Other University clubs:

How has that involvement contributed to your experience at University?

…………………………………………………………………………………………

…………………………………………………………………………………………

19. What did you like best about the Engineering School?

…………………………………………………………………………………………

…………………………………………………………………………………………

20. Is there any aspect of life within the Engineering school that you think needs improving?

…………………………………………………………………………………………

…………………………………………………………………………………………

21. Do you feel you have achieved as well as you expected in your engineering degree?

…………………………………………………………………………………………

…………………………………………………………………………………………

(This page for female students)

As a woman studying in the School of Engineering your experiences may differ from those of your male colleagues. Please comment from your own experience.

22. In what ways has being female within the School of Engineering affected your time at university - in positive and/or negative ways?

……………………………………………………………………………………….

………………………………………………………………………………………….

23. Do you think that as a female you bring strengths/attributes to your coursework or organisation for it?

………………………………………………………………………………………..…

………………………………………………………………………………………….

24. Do you think male students bring strengths/attributes to their coursework or organisation for it?

…………………………………………………………………………………………

…………………………………………………………………………………………

25. Do you think there are factors that might affect learning and performance in engineering other than gender. What might these be?

………………………………………………………………………………………….

………………………………………………………………………………………….

26. Have you found any areas of the course work particularly difficult?

………………………………………………………………………………………...

…………………………………………………………………………………………

27. Was this difficult for all students? ☐

Particularly for women students? ☐

29. Where did you receive positive support from during your studies?

…………………………………………………………………………………………

…………………………………………………………………………………………

30.. Have you come to any of the

WEN ( Women in Engineering Network) functions ? Yes ☐ No ☐

NEEWS ( Network for E&E women students) functions Yes ☐ No ☐

31. Do you think they are a good idea? Yes ☐ No ☐

Why? ……………………………………………………………………………

………………………………………………………………………………………….

If you have any further comments regarding your experiences in the School of Engineering and ways in which we could make it a personally and educationally enriching experience please feel free to continue over the page.

(This page for male students).

As a male student in the School of Engineering your experiences may differ from those of your female colleagues. Please comment from your own experience.

22. Can you suggest reasons why there are low numbers of female students in engineering?

…………………………………………………………………………………………

…………………………………………………………………………………………

1. Do you think there are differences in the ways male and female students experience their time in the School of Engineering?

…………………………………………………………………………………………

…………………………………………………………………………………………

2. Do you think that as a male you bring strengths/attributes to your coursework or organisation for it?

…………………………………………………………………………………………

…………………………………………………………………………………………....

3. Do you think female students bring strengths/attributes to their coursework or organisation for it?

…………………………………………………………………………………………

………………………………………………………………………………………...

4. Do you think there are factors that might affect learning and performance in engineering more than gender. What might these be?

………………………………………………………………………………………….

………………………………………………………………………………………….

5. How much interaction with female engineering students do you have?

Friendships and working together at engineering school Yes ☐ No ☐

Friendships and social life out of work hours Yes ☐ No ☐

Friendships with females mainly from your own ethnic group

Yes ☐ No ☐

6. Are you aware that there is a student group called WEN ( women in engineering network)?

Yes ☐ No ☐

30. Do you think this is a good idea? Yes ☐ No ☐

Why? ………………………………………………………………………………………

………………………………………………………………………………………….

If you have any further comments regarding your experiences in the School of Engineering and ways in which we could make it a personally and educationally enriching experience please feel free to continue over the page.

# APPENDIX 4

## STAFF QUESTIONNAIRE
## (Distributed October 1997)

**Please circle the appropriate option:**

**Position:** Tutor Lecturer Sen. Lecturer Assoc. Professor Professor

**Gender:** Male Female

**Ethnic Origin**:......................................................................

How many years have you been on the staff at the University of Auckland: ............

Please answer the following questions as fully as you can. (Feel free to continue any question on extra paper ). Your personal opinion is valuable.

**<u>Questions:</u>**

**<u>Part A - Entry to Engineering</u>**

1. What do you consider the main reasons for the low representation of women in tertiary engineering courses.
   ..........................................................................................................................
   ..........................................................................................................................

2. What strategies do you think might be effective at increasing the numbers of women in engineering?
   ……..…......................................................................................................................
   ..........................................................................................................................

3. Do you think women students should receive any special treatment or incentives to enrol in engineering courses? Yes No
   Please explain your reasoning:
   ..........................................................................................................................
   ..........................................................................................................................

**<u>Part B - The Learning Environment</u>**

4. Do you notice any differences in the way in which women and men students go about their study/ learning ? If so please explain.
   ..........................................................................................................................
   ..........................................................................................................................

5. In your experience, are there any aspects of your course that you think are either easier or more difficult for your women students.
   ..........................................................................................................................
   ..........................................................................................................................

6. Do you think the content of the courses you teach is of equal interest to women and men?
..........................................................................................................................
..........................................................................................................................

7. What comments can you make on women's participation in class and/or practical situations?
..........................................................................................................................
..........................................................................................................................

8. The term "gender-inclusive curriculum" has been used in a secondary teaching situation. Have you any ideas what this might mean for engineering education?
..........................................................................................................................
..........................................................................................................................

9. What comments do you have about the level of women's performance in your courses?
..........................................................................................................................
..........................................................................................................................

10. Have you noticed differing levels of personal confidence between your male and female students?
..........................................................................................................................
..........................................................................................................................

11. Do you believe there are other factors that might affect learning style and performance more than gender? What might these be?
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

**<u>Part C- Change</u>**

As well as other changes in the last twenty years, the numbers of female students at the School of Engineering have increased.

12. As the proportion of female students has risen (though not necessarily because of it), have you noticed any changes:
(a) in your teaching
..........................................................................................................................
..........................................................................................................................

(b) in the way staff and students relate to one another
..........................................................................................................................
..........................................................................................................................

(c) in the classroom environment
..........................................................................................................................
..........................................................................................................................

(d) in any other ways?
...............................................................................................................
...............................................................................................................

13. Do you view these changes as positive or negative? - please comment
...............................................................................................................
...............................................................................................................
...............................................................................................................

14. What do you perceive as the main reasons for the increases in female numbers?.
...............................................................................................................
...............................................................................................................
...............................................................................................................

15. From time to time an event or happening may occur which could be called a “critical incident” that triggered a change in attitude in your own or faculty’s thinking on issues of women in engineering. Briefly outline any such “incident” you can recall.
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

**<u>Part D General</u>**

16. In your opinion are the low numbers of women in the engineering profession a problem?
Please comment:
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

**Thank you for the time and energy you have put into answering this questionnaire. It is most appreciated.**

# APPENDIX 5

**Interview schedule for 1996 female final year students**

These questions guided the first cycle of interviews with female students in their final year of Engineering.

**Entry to engineering**

Please tell me about your family and schooling background?

When did you think of engineering as a possible course? And who influenced that decision?

Where did you get information about engineering from?

Why engineering? Why Auckland University and why did you choose (your specialization)?

**The University Experience - The undergraduate years.**

Tell me about your first year - how did you find that?

Now tell me about the other years - a sort of narrative - whatever you remember

What did you like most about your time in engineering school?

What did you like least about your time in engineering school?

What were your favourite courses?  why was that?

Which courses did you like least? why was that?

Was there any reliance on prior knowledge?

Can you remember any particularly powerful learning experience? a course or paper that you really felt you got a lot out of ?

Did your discipline provide many opportunities for work  or projects in a group or team situation - can you tell me how you found that? Who did what? Who decided who did what? Did you think it was a good way to learn?

What sort of experience was your final year project? How did you handle the partnership? Relationship with the supervisor?

How many women were there in your class? Did you form close friendships with any of them?

How were you received by the male students? How did you get on with them?

Engineering students often speak of a strong sense of belonging to their class group - what was your experience?

Do you think that there were differences in the way male and female students approached their work or learned things?

How were you received by the lecturers? How familiar and easy were relationships? Did you use titles or names? How comfortable were you in asking questions?

Tell me about jokes, humour, or language used by lecturers or other students - was this sexist, racist, patronising... often, occasionally, never?

Harassment is a word that can mean many things, not just physical, it is really any form of language or actions that are unwanted. Did you, or others that you know of, experience this in any way at the School of Engineering?

Who did you study with and/ or hang around with?

Did you take part in the social activities of the Engineering School, either through the Engineering Society or with your class. Tell me about these. What sort of activities? .Did you enjoy them?

Do you feel that young women consciously or unconciously seek to become "one of the guys" ?

**Outcomes**

Did you feel you achieved as well as you expected in your Engineering degree?

How do you feel about looking for work as an engineer? What sort of things do you feel you are good at - as an engineer? Do you have areas you don't feel confident about - as an engineer?

**Women in Engineering**

Do you feel women should be encouraged to take part in engineering?

What barriers to women taking engineering might still exist?

Do you think women in engineering programs and initiatives are needed? Any comments?

Did you take part in WEN /NEEWS activities?

Do you think there is a place for groups such as WEN/ NEEWS?

Are there any other aspects of your time at the engineering school that we have not covered?

# APPENDIX 6

### Interview schedule for Male final year students and new graduates

*Start with the following focus areas, and follow up leads which might provide further information on practices, behaviours, tacit knowledge and understandings.*

- What motivated your choice of engineering? Who or what influenced your decision? Hobbies?
- Your first few weeks here, what stands out in your memory?
- What characterises engineers and engineering?
- What is thinking as an engineer? How are you taught that?
- What 3 or 4 factors really stand out when you think of your time at the School of Engineering?

The themes listed below arose from responses to the questionnaires, and from earlier interviews. Use them as starting points if they do not arise from the discussion emerging from the broad band questions above.

**Workload**

What words come to mind? Tell me about the workload – has it varied much over the years?
Stress? How is that dealt with?

**Social interactions**

Tell me about the social interactions that take place within the school of engineering? How do you feel you fit into that side of life within the school?

AUES – have you taken part? Which activities ?

Tell me about your class – was it a close group, did you things together?

How have you fitted in?

Who do you hang around with? Are these friends for academic/study reasons or do you mix socially as well?

Are there people who don't really fit in?

Are there sub groups within your class or within the school?

Humour – what kind of joking?  Does it ever get sexist or racist?

**Professional unity**

Do engineers think of themselves with a special identity ?

What do other students/community think about engineering students?

How does engineering compare to other degrees? BA – BSc…

How are they different? Are the students different?

**Teaching and learning**

What aspects of engineering education stood out for you?

Is there an engineering way of thinking? How are you taught that?

What was a 'good' lecturer – and a bad one?

What was the predominant way of learning? Was that the way you think you would learn best?

Group or team skills – were they taught? Valued?

What was your experience of project  based learning?

Did your course include real life applications? Examples?

Has the course trained you for a career in professional engineering?
What skills have you learned?

Were there differences between the disciplines?  How could you describe these?

**Female students**

How many female students were there in your class?

Did you get to know other female students? In what roles?

How do they cope with life and the course at engineering?

Do you think females and males experience their study of engineering differently? Explain

**Other ethnic groups**

To what extent do you think different ethnic groups might "do it differently"

# APPENDIX 7

## Interview schedule used with Academic Staff – 1997/98

### Personal

Tell me about your background - family, education and career

What do you like best about your work here? What do you like least?

How accessible to students are you? What sort of matters do they come to you to discuss?

Tell me about your normal working day - hours, morning tea? Lunch? Exercise?

Departmental / faculty colleagues - do you mix with them socially? Meet after hours?

Has this always been the same?

If you want to "succeed" as an academic - what is most important? How do you find that sort of thing out? Are there tensions/difficulties in our system?

What do you see as the major goals of the new curriculum?

What provided the impetus/motivation for the implementation of the new curriculum?

How is it working in your department - what is going well, what are difficulties?

The current student body - in what ways does it differ from the time when you were a student, and your early days as a staff member?

Could you comment on changes in your own teaching style and methods of assessment - what motivated these changes?

### Culture – Behaviours and Practices

What are some of the words, phrases that are used to describe engineers ? What sort of people are engineers?  What do you think the public image is of engineers?

How would you describe the "culture" of the School of Engineering? As distinct from other faculties of the University?

Do we have a strong culture? At staff level? At student level?

Are there subcultures? Within the faculty? Within departments?
How similar are the different departments in 'the way they do things' ?

Can you think of differences ..... in the type of student, staff, ways of doing things?

Do you feel you fit into this culture? Why or why not?

Are there people who do not fit in? What happens to them? Can you think of an example?

What are some of the changes that stand out over the last 10-15 years? At the School of Engineering/ University?

Can you describe ways that the ‘culture’ might have changed in the last 10-15 years? And reasons for those changes?

Can you think of a crisis faced either by your department or by the faculty - how did it respond?

What are some of the stories and legends that people tell here? What messages do they convey?

Who are our ‘heroes’ - outstanding students or staff? What are they remembered for?

Disagreements/conflicts are a normal part of group dynamics. What sorts of things do you and your colleagues ‘disagree’ on? examples?

You have probably visited/studied/taught elsewhere. What are features of ‘the way we do things’ that might show up as differences compared to these other institutions?

What makes engineering different to other scientific disciplines?

Events : What kind of events do you have - Social, related to courses, meetings? .......staff/staff, staff/student, … field trips? Typical?

Group work - do we encourage this? How often? How do we model this?
How do we handle assessment of Group work?

Teaching duties - how are they allocated? I have heard the term “brownie points” - what are they, what is the reward?

How does a new staff member learn about

a) systems/procedures

b) appropriate level of content/assessment

c) dress code/ use of titles/expected hours of work

d) promotion - unwritten/written rules

Is the under representation of women in engineering a problem?
What strategies do you believe are effective to “solve” the problem?

Internationally 15-20% seems to be a maximum participation level for women in engineering education. What barriers do you perceive exist to maintain this level?

Have you noticed differences in the way female and male students learn, or approach their studies? Confidence levels?

Do you believe that female students/engineers bring gender specific strengths and attributes to the profession and study of engineering? What might these be?

Do you believe that male students/engineers bring gender specific strengths and attributes to the profession and study of engineering? What might these be?

**Thank you for giving up your time and sharing your experience and knowledge with me today.**

# APPENDIX 8

## Interview Schedule – First year students

*Start with the following focus areas.*

- What motivated your choice of engineering? Who or what influenced your decision? Hobbies?
- Your first few weeks here, what stands out in your memory?
- What characterises engineers and engineering?
- What is thinking as an engineer? How are you taught that?
- What 3 or 4 factors really stand out when you think of your time at the School of Engineering?

*Use these questions as leading questions around the focus areas above, follow up leads which might provide further information on practices, behaviours, tacit knowledge and understandings.*

What influenced your choice of engineering as a course? And about when did you decide on engineering?

Did you have any experiences or hobbies that have proved useful?

Has it been what you expected?

What stands out in your memory of the first days and weeks at University this year? Do you remember any of what happened at orientation?

You are doing an elective paper in a different faculty – what sort of things are different to the way things are done in engineering – in the way we teach, the way you learn, thinking,……

If you were talking to a student coming to engineering this year what would you say about your first year?

What did you enjoy most in the last year?

What did you enjoy least in the last year?

It has been said that engineering education has its own culture, where culture relates to the "way things are done', what is valued, and norms of behaviour. What comments would you make on that statement? Do you think there is a distinctive "way of doing things" and what might some of those things be?

What is thinking as an engineer? How are you taught that?

Have you made friends here? Do you hang around with one group of people?

How friendly/unfriendly is the first year group? Do you think there are groups based on gender or race within the main group? How much do they mix?

Are there any students who don't seem to fit in?

Using the words competitive and co-operative, how would you describe the way first year students interact?

Do you work part time?

Did you take part in the university or school of engineering social activities? Tell me about them?

When you worked in design, projects were done in groups – tell me about your experience of working in groups? What role did you tend to take in the group?

Assessment of group work is always difficult – tell me about your experience of the group assessment you did for the mechanism project.

Did you work with males/females, or people from other cultures – how did this affect the working of the group?

Do you remember any lectures or instructions about how to work in groups?

For the boys:
The proportion of girls in engineering is still fairly low, do you have any idea of the %? From your own observations could you comment on the way you think the girls' experience of first year may have differed from your own.

For the girls:
The proportion of girls in engineering is still fairly low, do you have any idea of the %? From your own observations could you comment on the way you think your experience may have differed from the boys.

# APPENDIX 9

## Inventory of Documentation used in this study.

- University Mission Statements and Strategic Planning documentation 1995 - 2000
- Faculty and committee meeting minutes from 1996 to 2002
- Annual reports of the School of Engineering 1995 - 2002
- Accreditation review documentation 1995 and 2000.
- Policy Group meeting reports 1998 - 2000
- Documentation prepared for the consideration of changes to the BE curriculum and structure 1995
- Course and teaching evaluation documentation 1996 - 2000
- Statistics - enrolment data 1996 – 2002 incorporating GPE, ethnicity, gender, discipline
  - examination results for Part 1 papers 1997,1998 including gender
  - Graduation and Honours data 1996 - 2002
- Faculty publications such as prospectus, handbooks and publicity material from 1995 - 2002
- Engineering Society and other student publications 1996-99
- Copies of examination papers (1st year) for the years 1997, 98, 99
- Copies of examination papers for Part II, II, IV for 1998 for each discipline.
- Copies of assignments, project outlines and marking schedules for a range of courses.

# APPENDIX 10

## Codes used in analysis of interview transcripts

These codes were used in the data analysis of interview transcripts. The groupings were those suggested by Bogdan and Biklen (1982) but have been adapted to the needs and context of this study.

### Setting and context

| | |
|---|---|
| AU_COU | information about our undergraduate degree e.g. Class size, selective entry, in-house teaching, disciplines, |
| AU_PAR | Participation – mostly statistics and explanations |
| AU_PHY | Physical structures – eg tower block, lecture theatres, stand alone building |
| AU_HIS | History including gender, ethnicity, fees changes, ( might end up a category on its own. |

### Definition of situation codes

How subjects see themselves in relation to their setting.
Used for topics such as motivation -Why me and engineering?

| | |
|---|---|
| MOT_PAR | parental influence |
| MOT_JOB | job prospects and opportunities |
| MOT_MSC | useful ways of using ability in maths and science |
| MOT_TINK | tinkering experience ( hands-on) |

Also included codes to deal with student's personal perception of their own position within the culture

| | |
|---|---|
| PER_CH | changes in themselves in response to education |
| PER_SUC | their successes |
| PER_CUL | values, qualities of own culture |
| PER_LEA | preferred learning style |
| PER_SK | personal skills, and prior experience |
| PER_CON | issues of personal confidence |

### Perspectives and Activity codes

Included participants' view of the academic/learning environment including shared ways of doing – behaviour and practices rather than views of each other or other people – "the way we do things round here".

| | |
|---|---|
| AC_CURR | curriculum content |
| AC_SK | skills and outcomes perceived as desirable ( may include outcomes and skills that are undesirable) |
| AC_WKL | comments about workload (note other codes for strategies) |
| AC_COU | comments about lectures, tutorials, labs and other regular activities |

| | |
|---|---|
| AC_PRO | projects/ assignments included comments re timing, (note separate codes for strategies) |
| AC_ASS | Assessment including exams and group assessment |
| AC_TEA | Teaching and teaching styles |
| AC_LEA | Learning environment – general 'ambience' type comments, as well as classroom behaviour |

### Subjects' way of thinking about people and objects

Used as "Engineers view of….

| | |
|---|---|
| EN_SCI | science (in contrast to engineering) |
| EN_NONE | non engineering students i.e. commerce, arts, |
| EN_ROLE | role and qualities of professional engineers |
| EN_ESTUD | fellow students in general – way of thinking, doing… |
| EN_REP | reputation from outsiders view |
| EN_STF | student view of staff |
| EN_HARD | engineering hardness |
| EN_DIV | diversity of cultures |
| EN_CLASS | class and classmates |
| EN_ID | their identity as engineers |
| EN_NAME | names people use about each other eg party animal, local terminology |
| EN_WAY | the engineering way of thinking |

The following group of codes started as EN_GEN ( engineering view of gender) but expanded to a separate set of codes based on participants' views around gender

| | |
|---|---|
| GEN_SK | differentiating skills according to male or female |
| GEN_EXP | differentiating experiences according to male or female |
| GEN_CUL | issues of gender that are linked to culture or ethnicity |
| GEN_ID | view of themselves as women/feminine ( or men/masculine) |
| GEN_STF | differential staff reactions to gendered participants |

### Process Codes

Sequences of events, passages from one status to another

| | |
|---|---|
| TR_UNIV | transition to university |
| TR_NZ | transition to NZ for new immigrants |
| TR_DEPT | issues around department choice at the end of first year |
| TR_DEG | transitions and changes through the degree |
| TR_WORK | transition to employment |

### Event codes

Events that were not regular or timetabled

| | |
|---|---|
| EV_AUES | engineering society event participation |
| EV_OTH | social events outside engineering school |
| EV_OR | orientation |
| EV_WEN | WEN events |

| | |
|---|---|
| EV_PER | perception of engineering society events ( not participation) |
| EV_STF | staff functions |

### Strategy codes

Strategies, ploys, tactics, methods, ways people accomplish things

| | |
|---|---|
| ST _SUP | support strategies - friends, group, stress relief |
| ST_COOP | cooperation/competition |
| ST_TIM | time management |
| ST_CHEA | Cheating |
| STGRP | strategies used in groups |

### Relationship and Social structure codes

Regular patterns of interactions that are not officially defined by an organisational role eg friendships, romances, enemies, mentors, cliques,…

| | |
|---|---|
| REL_EFR | Engineering friends |
| REF_FF | female-female friendships |
| REL_MF | cross gender friendships – not romantic |
| REL_ROM | romantic relationships |
| REL_NE | non- engineering friendships |
| REL_CUL | interactions, relationships across or within cultures (ethnicities) |
| REL_STF | relationships/ interactions with staff |

# APPENDIX 11

# APPENDIX 11

## IPENZ Requirements for Initial Academic Education of Professional Engineers

**Note: For copyright reasons Appendix 11 has not been reproduced.**

IPENZ Requirements for Initial Academic Education of Professional Engineers

**(Co-ordinator, ADT Project, Curtin University of Technology, 20.1.04)**

# APPENDIX 12

### Statistical analysis of Part 1 grades 1998

The grades for all Part I courses, available as percentage scores, were analysed for possible gender differences using the measure *d*, a standardized mean difference, which has been referred to as an “effect size”[1]. This statistic computes the difference between the female mean and the male mean, divided by the pooled within-group standard deviation, and provides a measure of how far apart the group means are in standard deviation units.

$$\text{Effect size} = d = \frac{\bar{x}_m - \bar{x}_f}{\sigma_{mf}}$$

The magnitude of the effect size has been seen to provide a quantitative estimate of practical significance[2] and has been used in meta-analyses of gender differences within mathematics and science[3].

Table A12.1 Statistics for Part 1 Engineering courses 1998.

| **Course** | $n_{mf}$ | $n_m$ | $n_f$ | $\bar{x}_{mf}$ | $\bar{x}_m$ | $\bar{x}_f$ | $\sigma_{mf}$ | $\sigma_m$ | $\sigma_f$ | ***d*** |
|---|---|---|---|---|---|---|---|---|---|---|
| Mathematical Modelling | 441 | 342 | 99 | 67.17 | 67.21 | 67.05 | 14.50 | 14.70 | 13.80 | 0.01 |
| Engineering Mechanics | 445 | 346 | 99 | 63.53 | 64.58 | 59.88 | 16.80 | 16.70 | 16.90 | **0.28** |
| Engineering Design | 424 | 331 | 95 | 67.93 | 68.12 | 67.32 | 9.78 | 10.40 | 7.45 | 0.06 |
| Environmental Principles | 445 | 343 | 99 | 63.53 | 59.05 | 61.32 | 16.80 | 10.69 | 10.80 | **-0.21** |
| Materials Science | 434 | 331 | 96 | 66.41 | 66.80 | 66.09 | 15.58 | 15.54 | 14.93 | -0.04 |
| Electrical Eng Systems | 433 | 330 | 95 | 62.33 | 62.60 | 61.71 | 14.30 | 14.45 | 13.30 | 0.06 |
| Engineering Computing | 433 | 336 | 97 | 68.18 | 68.27 | 67.89 | 13.50 | 13.70 | 12.90 | 0.03 |

The effect sizes calculated from the final results of the seven Part 1 courses in 1998 (Table A12.1) indicated that, for all but two courses (Engineering Mechanics and

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[1] Kirk, R.E. (1969) Practical significance: A concept whose time has come. *Educational and Psychological measurement*, *56*, 746 – 759.
[2] Plucker, J.A., & Ball, D. (1996). Comment on “Learning science in a cooperative setting: Academic achievement and affective outcomes.” *Journal of Research in Science Teaching, 33,* 677-679.
[3] Linn, M.C. & Hyde, J.S. (1989) Gender, Mathematics and Science. *Educational Researcher, 18, 8, 17-19, 22-27.*

Environmental Principles in bold font in the table above), gender differences were trivial. Statistical significance testing has been used for between group comparisons but Rennie (1998)[4] suggested that effect sizes provide a more useful indication of practical significance. She argued that for a large group an effect size of 0.1 might be statistically significant although barely noticeable, whereas an effect size of 0.2 or more, whilst still small, was likely to indicate a difference worth investigating for practical or educational value. The results for both Engineering Mechanics and Environmental Principles demonstrated statistically significant gender differences, Engineering Mechanics at the1% level and Environmental Principles at the 5% level. The effect sizes, 0.28 in favour of males for Engineering Mechanics and 0.21 in favour of females, indicated relatively small but noticeable gender differences. After checking that the data were normally distributed by using a p-p plot, the comparison of probability distribution graphs (Figure A12.1) for Engineering Mechanics demonstrated this gender difference.  It also confirmed, however, the considerable overlap in the distribution of results for male and female students.

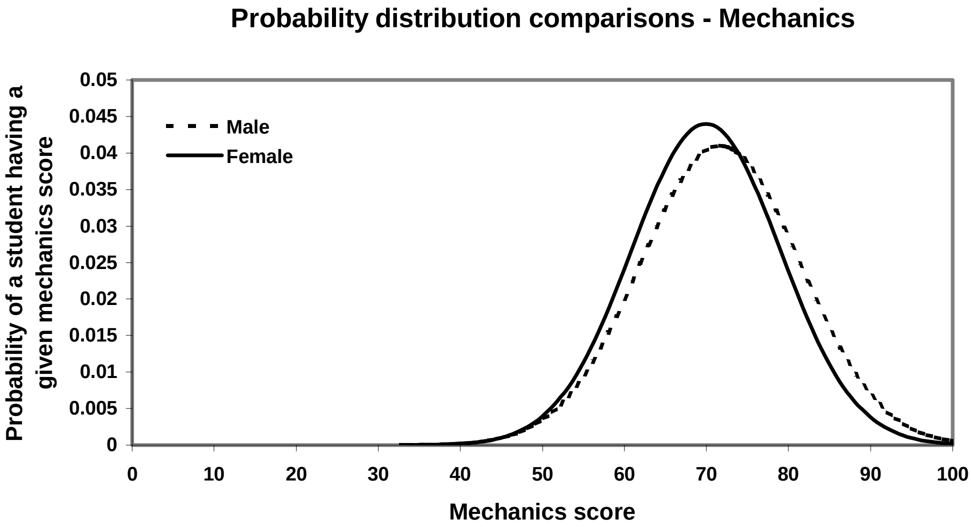


Figure A12.1 Comparative probability distribution of scores for Engineering Mechanics 1998

The NZ University Entrance Bursary scores, used for selection of the majority (approx. 85%) of Part 1 students, were also analysed (Table A12.2). Although the male mean was higher than that for female students, the effect size of 0.14 indicated that gender differences in entry qualification were  barely noticeable, and could not,

[4] Rennie, L. (1998) Improving the interpretation and reporting of quantitative research. *Journal of Research in Science Teaching, 35 ,2,* 237-248.

in themselves, be used to account for the more noticeable differences in Engineering Mechanics and Environmental Principles.

Table A12.2 Statistics for NZ University Entrance Bursary scores for Part 1 1998.

| | $n_{mf}$ | $n_m$ | $n_f$ | $\bar{x}_{mf}$ | $\bar{x}_m$ | $\bar{x}_f$ | $\sigma_{mf}$ | $\sigma_m$ | $\sigma_f$ | $d$ |
|---|---|---|---|---|---|---|---|---|---|---|
| NZUEB | 379 | 287 | 92 | 356.8 | 358.2 | 352.3 | 41.2 | 42.1 | 38.3 | 0.14 |

For the Engineering Design course, the effect size was trivial, but the larger standard deviation in the scores for males relative to females demonstrated a possible cause of the perception that males were better at Design. The data revealed that whereas 29% of the class were female, only 10% of the top 10% of the class were female. This is well illustrated in the following comparative probability distribution graphs (Figure A12.2).

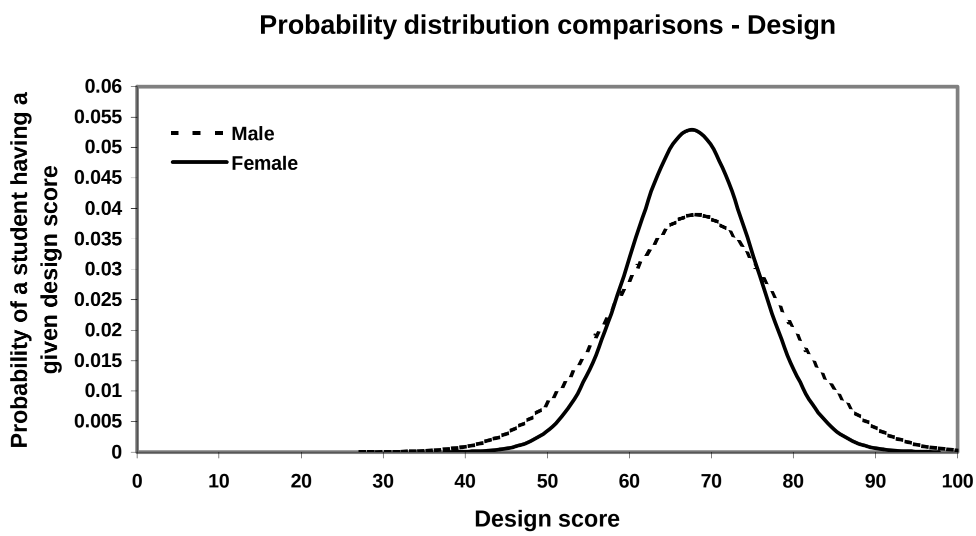


Figure A12.2 Comparative probability distribution of scores for Engineering Design 1998

Note:

| | | | |
|---|---|---|---|
| $n_{mf}$ | = total number of male and female students | $n_m$ | = total number of male students |
| $n_f$ | = total number of female students | $\bar{x}_{mf}$ | = mean score for whole sample |
| $\bar{x}_m$ | = mean score for male students | $\bar{x}_f$ | = mean score for female students |
| $\sigma_{mf}$ | = standard deviation for whole sample | $\sigma_m$ | = standard deviation for male students |
| $\sigma_f$ | = standard deviation for female students | $d$ | = effect size as defined above. |

# APPENDIX 13

## Values and cultural norms manifested by Artefacts

The Artefacts presented as findings in Chapter 4 were the cultural manifestations of the values and cultural norms listed below in table form. Each value or norm has been cross-referenced to the section in Chapter 4 which discussed the Artefact from which it was identified. Some values have been named as espoused rather than manifested because a mission statement, for example, cannot be assumed to be manifested in the lived experience of behaviours and practices which provide the evidence for cultural norms. The interaction with gender, either as gendered values and norms, or as participants formed and maintained gendered identities has been commented on for some of these cultural features. Those with implications for gender have been indexed with a *.

| **Value or cultural norm** | **Source of evidence** |
|---|---|
| Value<br>Excellence in teaching and research | 4.2(espoused) |
| Norm<br>Core of long serving male staff | 4.7.2 |
| Value<br>Student culture – quality of experience | 4.2(espoused), 4.3.2 |
| Value/Norm<br>High status/worth of the degree | 4.2(espoused),4.3.1(espoused), 4.7 |
| Norm<br>Sense of belonging and collective pride as engineers | 4.3.1, 4.3.2, 4.4.1, 4.4.2, 4.6.1*, 4.7 |
| Value/Norm<br>Interdepartmental integration and cooperation | 4.2, 4.4.1, 4.4.3* |
| Norm<br>All study-related activities in one building- | 4.4.1, 4.4.2*, 4.4.4 |
| Norm<br>For engineering to see itself as self sufficient from rest of campus | 4.2, 4.4.1, 4.4.2 |
| Value<br>Engineers socially and environmentally responsible with good communication skills | 4.3.1(espoused) |
| Norm<br>Alcohol strongly linked to engineering student society social activities | 4.3.2* |

| | |
|---|---|
| Value<br>Increased participation by women students and staff in engineering education | 4.2.1*(espoused), 4.3.1*,4.3.1.1*, 4.7.1* |
| Norm<br>Relatively high proportion of women students | 4.7.2* |
| Norm<br>A ‘blokey’ male perspective in student publications | 4.3.2* |
| Norm<br>Dress is not important except to signify professionalism | 4.6* |
| Norm<br>Artwork displayed creativity and innovation in engineering solutions | 4.5, 4.3.1 |
| Norm<br>Women students use dress to identify dual identity – women and engineers | 4.6.1*. |
| Norm<br>Vulgarity and obscenity not condoned by staff | 4.6.1* |
| Norm<br>Wide ethnic diversity | 4.3.1, 4.7.1* |

# APPENDIX 14

## Values and cultural norms manifested by Practices

The Practices presented as findings in Chapter 5 were the cultural manifestations of values and cultural norms listed below in table form. Each value or norm has been cross-referenced to the section in Chapter 5 which discussed the Practice from which it was identified. The interaction with gender, either as gendered values and norms, or as participants formed and maintained gendered identities has been commented on for some of these cultural features. Those with implications for gender have been indexed with a *.

| Value or cultural Norm | Source of evidence |
|---|---|
| Value/Norm<br>Theory related to applications | 5.2.2, 5.2.5*, 5.2.6, 5.2.7, 5.3.1.1, 5.3.1.2* |
| Value<br>Communication skills | 5.2.2, 5.2.3, 5.2.10*, 5.3.1.1, 5.3.1.4, 5.3.1.5, 5.3.1.6 |
| Value/norm<br>High proportion of Project based learning | 5.2.2, 5.2.3, 5.2.7, 5.2.8, 5.2.11, 5.3.1.1, 5.3.2, 5.3.3, 5.3.4, 5.5.2 |
| Norm<br>Majority of teaching traditional teacher-centred | 5.2.9, 5.3.1.2 |
| Norm<br>Pragmatism/ tradeoffs between ideals and reality for large classes, and resource constraints | 5.2.8, 5.2.9, 5.3.1.3, 5.3.1.4 |
| Value/Norm<br>Professional skills including issues of management, environmental and social responsibility | 5.2.2, 5.2.4, 5.3.1.4, 5.3.1.5, 5.3.2, 5.5.1 |
| Value<br>Common first year as introduction to the “Engineering Way” | 5.2.2, 5.2.3 |
| Value<br>Design - the essence of the “engineering way” | 5.2.2, 5.2.3, 5.2.6, 5.2.7, 5.6 |
| Value/norm<br>Design courses – demonstrates valuing of process | 5.3, 5.3.1.6, 5.3.4 |
| Value/norm<br>Design – demonstrates value of “must work” – outcome | 5.2.6, 5.3.4 |
| Norm<br>Mathematics pervasive and essential to demonstrate understanding | 5.2.3, 5.2.4, 5.2.6, 5.3.1.1, 5.3.1.2, 5.3.1.3, 5.3.1.5, 5.3.2, |

| | |
|---|---|
| Value<br>Essential technical knowledge | 5.2.2, 5.2.7, 5.3.2 |
| Norm<br>Use Diagrams/ graphics to demonstrate understanding | 5.2.7, 5.3.1.2, 5.3.1.4, 5.3.1.6 |
| Norm<br>Academic input from other disciplines not valued | 5.2.2, 5.7 |
| Norm<br>Staff not trained in teaching or educational theory | 5.2.9, 5.2.10, 5.2.11 |
| Norm<br>Problem solving major focus<br>– particularly emphasis on best, optimal solutions | 5.2.6, 5.2.7, 5.2.11, 5.3.1.1, 5.3.2 |
| Norm<br>Design and projects taught by challenge and expectation | 5.3.4 |
| Norm<br>Interdepartmental cooperation with cross disciplinary teaching and research | 5.2.9 |
| Norm<br>Students have instrumental focus – want grades not learning, want spoonfeeding | 5.2.6, 5.2.9 |
| Norm<br>Teaching practices viewed as gender free | 5.2.10*, 5.4.2* |
| Norm<br>High proportion of on course assessment often open ended | 5.3.1.1, 5.3.1.5, 5.3.1.6, 5.3.2 |
| Norm<br>Assessment marks “hard earned” | 5.3.1.3, 5.3.1.4 |
| Norm<br>Reductionist methodology common | 5.2.6, 5.2.7, 5.3.1.2 |
| Value<br>Group and team work skills | 5.2.3, 5.3.1.6, 5.3.3, 5.3.3.2, 5.5.1 |
| Norm<br>Assessment individual and ranked | 5.3, 5.3.3 |
| Value<br>Excellence in academic achievement | 5.3 |
| Norm<br>Strong sense of cohesive engineering identity | 5.5.1, 5.5.2, 5.5.4, 5.5.5, 5.7 |
| Norm<br>Engineering Student Society traditional face of engineering | 5.5.1, 5.5.5* |

| | |
|---|---|
| Norm<br>Excessive alcohol consumption at Engineering Student Society events | 5.5.1, 5.5.5* |
| Norm<br>“Bloke” is stereotype of engineer | 5.5.1, 5.5.5* |
| Norm<br>Contradiction between espoused valuing of teaching and faculty perceptions | 5.2.8, 5.4.1, 5.4.2, |
| Norm<br>Staff social functions valued but only one or two per year | 5.5.3 |
| Norm<br>Staff student functions focused on celebratory occasions | 5.5.4 |
| Norm<br>Women students had regular social events | 5.5.5* |
| Norm<br>Women only social events viewed as divisive | 5.5.5* |
| Norm<br>Close links with industry and the profession | 5.6 |
| Norm<br>Staff and students view themselves as separate from other faculties | 5.7 |

# APPENDIX 15

### Values and cultural norms manifested by Behaviours

The Behaviours presented as findings in Chapter 6 were the cultural manifestations of the values and cultural norms listed below in table form. Each value or norm has been cross-referenced to the section in Chapter 6 which discussed the Behaviour from which it was identified. The interaction with gender, either as gendered values and norms, or as participants formed and maintained gendered identities has been commented on for some of these cultural features. Those with implications for gender have been indexed with a *.

| **Value or cultural Norm** | **Source of evidence** |
|---|---|
| Norm<br>Work under pressure with tight time constraints | 6.2.1, 6.2.4* |
| Norm<br>To equate learning with shared hardship | 6.2.1, 6.2.3.2 |
| Norm<br>Feel pride and sense of worth in "surviving" | 6.2.1, 6.2.3.3, 6.2.4, 6.4.4 |
| Norm<br>Learn by challenge and stretch | 6.2.3.3* |
| Norm<br>Instrumentalist or surface approach to learning | 6.2.3.1, 6.2.5.1 |
| Norm<br>Students co-operate in order to compete | 6.2.2 |
| Norm<br>Considerable copying and sharing of assignments | 6.2.3.2 |
| Value / Norm<br>Friends and friendship groups important for academic survival | 6.2.2*, 6.2.4*, 6.2.5*, 6.3.3, 6.3.3.1, 6.3.3.2* |
| Norm<br>Pride and sense of belonging in engineering | 6.3.3, 6.4.4 |
| Norm<br>To be male | 6.3.2, 6.3.3.2*, 6.4.3*, 6.5* |
| Norm<br>Perception that female engineering students are different to other females | 6.2.1*, 6.5* |
| Value<br>Time management skills | 6.2.4, 6.2.6* |
| Norm<br>Teamwork skills learned by repeated exposure rather than taught | 6.2.6 |

| | |
|---|---|
| Norm<br>Women and some men entering without practical tinkering experience | 6.2.6* |
| Norm<br>Stereotypical gender roles in group work in early years | 6.2.6* |
| Norm<br>Not to show emotion in public | 6.2.4* |
| Norm<br>Strength in practical, engineering-related skills associated with masculinity | 6.2.6*, 6.5* |
| Norm<br>Women feel accepted and comfortable in relationships with male peers | 6.2.5.3*, 6.3.3.2* |
| Norm<br>Awareness of sexuality and gendered identities present but sublimated | 6.3.3.2* |
| Norm<br>Womens groups seen as implying weakness | 6.3.3.2* |
| Norm<br>Womens groups seen as divisive | 6.3.3.2* |
| Norm<br>Ethnic affiliation stronger than gender | 6.3.3.2* |
| Norm<br>Women highly visible in class groups | 6.2.5.3*, 6.3.2 |
| Norm<br>Close relationships with classmates | 6.2.5.1, 6.2.5.3*, 6.3.3, 6.3.3.1, 6.3.3.2* |
| Norm<br>Staff-student relationships informal especially in senior years | 6.3.2 |
| Norm<br>Perception that women students receive help more readily than male peers | 6.3.2* |
| Norm<br>Use of language direct and succinct | 6.4.1 |
| Norm<br>Visual language of diagrams, symbols, graphs, flow diagrams to communicate | 6.4.1 |
| Norm<br>Mathematics used as a language | 6.4.1 |
| Norm<br>Humour used to emphasise pride and engineering identity | 6.4.4* |
| Norm<br>Sexist humour prevalent in informal settings | 6.4.4* |
| Norm<br>Use of gender inclusive language in formal settings | 6.4.3* |