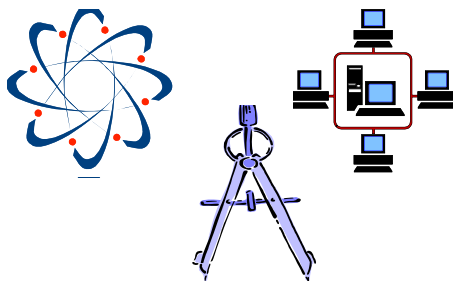


# **Equity and Diversity in Science, Engineering and Technology Education**



By

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# EQUITY AND DIVERSITY IN SCIENCE, ENGINEERING AND TECHNOLOGY EDUCATION

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## Executive Summary

### *Introduction*

The aim of the Equity and Diversity in Science, Engineering, and Technology Education project was to extend the understanding of staff in the Division of Information Technology, Engineering, and the Environment of the issues surrounding increased diversity in the student body, and to suggest areas of new research in this field. This report provides a literature review, some examples of good practice, and Divisional equity and diversity data.

### *The Theoretical Issues*

Issues of equity and diversity in science, engineering and technology (SET) education are important to the Division of ITEE, which aims to improve the equity profile, and to increase the diversity, of the student body. The research shows that a mixture of both visionary and pragmatic approaches are often applied to achieving these aims.

Early research on the access and success of equity and diversity students in SET concentrated principally on (negative) 'dispositional' factors amongst female students, which prevented them from opting for SET tertiary education. From these investigations, interest developed in gender differences in the cognitive domain, and then to the influences of teachers' beliefs and expectations on the learning of students from different social and cultural groups. A subsequent development has been to explore the positive impact on aspects of the learning environment of increased participation by equity and diversity students. Some researchers have challenged the role of 'western' science and scientific enquiry in privileging certain social and cultural groups.

### *The Division's Equity and Diversity Student Profile*

An analysis of the Division's equity and diversity performance shows in summary:

- Success in recruiting low SES and NESB students, but difficulty in retention
- Moderate success in recruiting disabled students, but again less success in retention
- Wide range of performance in recruiting international students
- Less success in recruiting rural and isolated students; their retention and success rates variable
- Recruitment of female engineering students improving, steady for other Schools. Retention and success rates variable
- Little success with recruitment of Aboriginal and Torres Strait Islander students. Retention and success better

### *Access, Retention and Success, and Diversity Strategies*

A wide range of strategies has been adopted internationally, nationally and within this University to improve **access** to SET courses. These include recruitment and awareness programs, preparatory programs and special admissions schemes and scholarships for targeted groups. Other strategies have been designed at both the institutional and individual levels to improve the **retention and success** of equity and diversity students, which include changing SET structure and culture.

Advantages for universities arising from student **diversity** include improved educational quality, a better preparation for professional practice, and contributing informed and responsible graduates to mainstream society. Organisational and classroom strategies have been identified and used to improve intellectual and practical connection between students and diverse social and professional communities.

### *Implications for the Division*

The Division of ITEE has made considerable efforts and initiated a range of strategies to address equity and diversity issues. Many of these have been fragmented, and relied heavily on the drive, enthusiasm, and commitment of individual members of staff. For consistent, credible, and successful progress towards equity and diversity aims, a more integrated approach at Divisional level is necessary, to consolidate and sustain these initiatives.

## Chapter 1: Introduction

### ***Background***

The Equity and Diversity in Science, Engineering and Technology Education (EDSETE) project was a cross-disciplinary research project undertaken in 2000 by members of the Technology in Higher Education Research Group (THERG) in the Division of Information Technology, Engineering and the Environment (DITEE) and in the School of Education, at the University of South Australia.

The project was instigated by recognition of the value of staff and student diversity in enhancing the quality of education, and the wish to disseminate this perspective. Consequently, one aspect explored in this document is the advantages which this diversity brings to science, engineering, and technology (SET) education. Other areas of interest to the researchers are the ongoing issues of access and success for students who have not traditionally undertaken SET higher education. The outcomes of the project presented in this document are: a literature review, Divisional equity and diversity data and initiatives, and some examples of good practice from elsewhere in Australia and in other countries with a similar culture.

### ***Introduction***

The project had two aims:

- to extend the understanding of staff in the DITEE of the issues surrounding increased diversity in the student body
- to suggest areas of new research in this field.

The issues surrounding increased diversity in the student body include the advantages which result from this diversity, as well as the equity aims of improving the access and success of students from social and cultural groups which have not traditionally entered higher education in the SET disciplines.

These issues are important to the Division for at least two reasons, one visionary and one pragmatic. Starting with the visionary one: as educators we want to reveal the advantages of acquiring an education in our discipline to students who will share our enthusiasm. We know that the quality of our courses is enhanced when the students are lively, able, and motivated, and especially so if they can contribute new perspectives to our courses. We derive satisfaction from the knowledge that in their subsequent working lives our successful students will contribute to the community not only in the industries and occupations related to our discipline, but in a wider sense as well, as responsible citizens. We hope that the most creative students will continue with us for postgraduate studies and make a significant contribution to the development of our discipline. For all these reasons we are always on the lookout for students who are going to contribute positively to the academic and occupational communities associated with our discipline as well as to society as a whole. We therefore do not wish to exclude any promising students from our programs, even if their prior academic experience falls short of our usual expectations of students joining our programs.

The pragmatically important reason for interest in this area relates to the goals of our institution. Equity performance is a Key Performance Indicator for Divisions and Schools. Plans, targets, and success in relation to the four DETYA indicators of equity performance (access, participation, retention, and success), are required annually by the University's Senior Management, and our

performance against these is rigorously monitored. We are also encouraged to recruit, and successfully graduate, international students because of the financial benefits they bring to the institution.

The issues affecting students in SET disciplines who come from diverse social and cultural groups fall into two main categories. The first of these: the educational and social value to all SET students of diversity amongst them, is so far under-researched in Australia. A number of studies have however emerged from the US during the nineties, which have evaluated the positive effects of universities' 'diversity' policies. Typically, these studies have found improvements in satisfaction and success of all students (Humphreys 1999, AACU 1999). THERG is interested in exploring these issues in an Australian context.

Our other area of interest is increasing the *access* and *success* of 'non-traditional'<sup>1</sup> students to higher education. Why do these students opt (or, for many of these groups, not opt) for higher SET education? Once they have decided to apply for SET study at university, are there any unnecessary barriers to their admission, bearing in mind that their backgrounds may have limited their opportunities to obtain the normal entry qualifications? Once enrolled, how successful are these students? Do students from 'non-traditional' groups have different values, perspectives and abilities from the majority groups, and if so, do these different attributes affect their progress and success? Do the attitudes and teaching methods of the lecturers affect the students from minority groups in different ways from the dominant group? Is there anything about a university's organisational structure which impacts differently on the learning opportunities of students from different social and cultural groups?

### **Terminology**

This Report focuses on groups of students from a diverse range of backgrounds. Until about twenty years ago the typical science and engineering student, in the English-speaking countries anyway, was young, white, middle-class, and male. Since the academic staff, and indeed all other professional scientists and engineers in these countries have been drawn from this pool, the overriding (or 'dominant') culture of these professions has been formed by 'western' and male values and perspectives.

The students of interest to this project are all those students who differ socially and culturally from the students described above as those who have traditionally opted for SET higher education. We are interested in the impact of these 'new' groups of students (such as women, those from non-English-speaking backgrounds, Indigenous students) on the culture of science and engineering education, as well as in the academic welfare of these new students themselves. While there are significant differences between these various groups of 'new' students, some educational issues are common to them all, and so (like many others before us) we have sought for an appropriate term which efficiently embraces all these 'new' SET students.

The terminology applied collectively to groups of students who have not traditionally opted for SET higher education has proved problematic because a descriptive term tends to become a label, and then a stereotype. Students from different backgrounds bring different values and perspectives to their studies. Often their preparation for higher education has been different from that of the traditional SET students. To lecturers, these different prior experiences tend to be the most obvious of the differences between these students and the 'traditional' ones (for example, difficulties with written English for students whose first language is not English, or lack of

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<sup>1</sup> This term is discussed in the next paragraph.

knowledge of mechanical or electronic parts of women and other students who have not had opportunities for ‘tinkering’ with machinery). Earlier, such gaps in students’ prior knowledge have been labelled ‘deficiencies’, needing ‘remedial’ treatment. Later, when it was recognised that these gaps in knowledge arose from the social and educational systems in which students had grown up, and not from any intellectual inferiority, the term ‘disadvantaged’ replaced ‘deficient’. Over time, the term ‘disadvantaged’, as well as successors such as ‘non-traditional’<sup>2</sup>, ‘minority’, or ‘non-dominant’ students have also acquired meanings often understood to be close to ‘intellectually inferior’, and have consequently become unacceptable in many educational and cultural communities.

In this Report we usually use the term ‘equity and diversity students’ when referring generally to all the students from the DETYA ‘equity groups’<sup>3</sup>, as well as international and mature-aged students. The terms used formerly however, such as ‘non-traditional’, ‘minority’, or ‘non-dominant’, even ‘disadvantaged’, appear in the literature we have consulted, depending on its age and its country of origin. The policies and strategies designed to support and ‘include’ these students alongside their culturally dominant peers are in most cases still valid and effective, even if the terminology used to describe these students collectively is not now acceptable. We therefore refer to this older literature in this Report, and sometimes for clarity use their terminology, if in our view it contributes positively to our objectives in preparing this Report.

### ***Structure of this Report***

There are seven Chapters and two Appendices in this Report. Following this introductory Chapter, Chapter 2 is a literature review of the theoretical equity and diversity issues in SET education. Chapter 3 gives an equity and diversity analysis of the Division’s student profile, Chapters 4, 5, and 6 provide literature reviews of higher education SET strategies to improve access; retention and success; and student diversity; respectively, illustrated by examples from the University of South Australia and elsewhere. Chapter 7 discusses the implications of all these findings for the Division. Appendix A lists the meanings of the abbreviations used, Appendix B shows in graphical form the percentages of students in the US studying the different sciences who are female, and Appendix C provides some additional models of the typical stages of development of an inclusive curriculum.

### ***Project Methodology***

Firstly, a literature review has been undertaken, looking for the theoretical and practical issues which arise from equity and diversity policies in the SET disciplines. Then, all the Division’s Schools and Institutes were approached and asked to provide information about their initiatives and procedures designed to promote equity and diversity in their student profile. Then information was collated about the current concerns, priorities and initiatives of the University’s and Division’s central units concerned with equity and diversity. At the same time, the project team explored equity and diversity practice in the disciplines represented in the DITEE in selected Australian and overseas universities, to determine what could be learned from the success of these other institutions in our areas of interest. Although a large amount of material

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<sup>2</sup> The term ‘non-traditional’ in this context (referring to groups who have not ‘traditionally’ opted for SET higher education) is particularly problematic since many Indigenous communities use the term ‘traditional’ to describe themselves and their way of life.

<sup>3</sup> Defined by DETYA as women, Indigenous students, students from a non-English-speaking background (NESB), students with a disability, isolated and rural students, and students with low socio-economic status (SES)

was collected from sources outside this University, much of it is similar, and it is not all reported here. Examples from other sources are only included in this Report, if in the view of the project team they contribute an new perspective or orientation to what is already going on in this University.

## Chapter 2: The theoretical issues

Chronologically, interest in the equity aspects of SET education pre-dated consideration of the advantages of diversity, and has developed largely from the recognition that women staff and students were poorly represented in most SET disciplines. Over time, consideration of the causes and consequences of this gender imbalance have resulted in a rich body of knowledge and understanding of a range of issues encompassing the impact of greater diversity amongst students in higher education. The consequences of this field of research have been far-reaching: not only has the representation in SET education and professions of women and other equity and diversity students improved (but in most fields has not yet achieved parity with male representation), but challenges to the nature of science itself have been raised by feminist scholars and those concerned with cross-cultural education. The following paragraphs provide an overview of this evolution, identifying the main themes and perspectives.

Research in this field is usually regarded as beginning around 1970, initially as an outcome of the feminist movement, but rapidly adopted by those interested in ethnic and other cross-cultural investigations (Rothenberg 1996). The research undertaken can be categorised into three main areas: the first two of these concern the *access* and *retention and success* of equity and diversity students in SET tertiary education. The third area is concerned with the benefits that *diversity* amongst students and professionals brings to SET tertiary education and the related professions.

The ‘access’ issues are those relating to students’ choices about tertiary study, as well as university policies and practices which support or impede the admission of equity and diversity students. The ‘retention and success’ issues are about the experiences of these students once enrolled for university study, how these experiences affect the retention of these students throughout their courses, and their eventual success. This distinction between access and success could be summarised by Glover’s (2000) terms (used in a different context<sup>4</sup>) as the difference between ‘getting in’ and ‘getting on’. While these differences are sufficiently marked to justify regarding ‘access’ and ‘success’ as two separate areas in this Report, there are some commonalities, outlined in the following paragraphs.

Much of the research about the access and success of equity and diversity students has been concerned with the ‘barriers’ faced by these students in entering and participating in tertiary education (Cross 1984, Ayre 1990, Bridgwood 1991, Rosser 1995). These studies have lately been subject to some disapproval, because some of their findings have been interpreted as identifying deficiencies or shortcomings in the students themselves (such as women engineering students expressing lack of confidence in their ability to succeed in engineering) (WISET 1995, FEFC 1996, Cronin, Cooper and Roger 1997). Yet many institutional equity policies are still based on the findings of this kind of research (which are very useful, for example, as a basis for effective marketing), and for this reason some of the research into barriers is referenced in this Report.

A study by Cross (1984, cited in Dececchi, Timperon and Dececchi 1998) identified three groups of barriers which impact on women’s educational opportunities. Other studies have identified similar barriers to exist for other equity and diversity students (Ellis 1997, for example). Cross

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<sup>4</sup> Glover introduced these terms in the context of women in scientific and engineering *employment*. She argues that although there have been some improvements in the number of women ‘getting in’ to these fields of employment, there has been little improvement in career progress (‘getting on’). Women are clustered in the lower paid and lower status jobs.

defined these barriers as situational, institutional, and dispositional, and we expand on these definitions below:

- *situational barriers* are those which arise from an individual's life circumstances at a particular time, such as lack of requisite university entry qualifications, or insufficient income to support a period of study
- *institutional barriers* arise from policies and procedures which impede the entry or success of equity and diversity students, such as strict adherence to qualifications-based admissions procedures, or the use of examination or other assessment techniques which favour students from socially and culturally dominant groups
- *dispositional barriers* are students' own attitudes and perceptions which may affect their choice of field of study, or their success within it. Indigenous students for example, may not be disposed towards studying science and engineering because they do not perceive these disciplines has having any direct benefit to their communities. Women may drop out of engineering courses because they decide they would prefer to qualify in a 'people' field than in a 'things' field. Teaching staff can cause dispositional barriers, if they have (and make it obvious that they have) different expectations of groups of students arising from their social or cultural backgrounds.

Finally, towards the end of this chapter we consider the advantages identified as arising from increased diversity amongst SET students in higher education. Humphreys indicates the direction of this kind of research:

It is clear from [the] growing body of evidence that diversity initiatives, from those that focus on access to campus climate to curriculum change to comprehensive institutional transformation, provide demonstrable benefits to all students, whatever their backgrounds and characteristics. There is considerable evidence that higher education's efforts to address diversity issues on campus and in the curriculum are fostering intellectual development, cultural knowledge, and interracial understanding among college students (Humphreys, 1999).

## **Access**

### **Introduction**

One of access issues in SET tertiary education is identifying what influences equity and diversity students' choice of discipline for tertiary study; another issue is the institutional policies and procedures which assist or prevent the enrolment of these students in SET courses. McIlwee and Robinson (1992) classified the factors which produce an individual's "... initial orientation towards engineering ..." (p. 24) into academic abilities, practical orientation, personal relationships, and the social context. Institutional policies and procedures which can improve the enrolments of equity and diversity students include factors like selection processes, special entry schemes, scholarships, and academic programs which are of particular interest to these groups of students.

### **Positive influences on orientation to SET**

In the mid nineteen-eighties, McIlwee and Robinson researched the problems and opportunities for women in engineering in the US. In their book, *Women in Engineering: Gender, Power and Workplace Culture* (1992) they describe the life-cycles of some women engineers, from high school through to career issues such as balancing family and professional life. Most of the findings of this study relating to the educational phase of these women's careers are also applicable to the issues surrounding the selection of SET study by members of other cultural groups. This section of the Report is accordingly structured around the three factors identified by

McIlwee and Robinson as being most influential: academic abilities, pragmatic career choice, and personal relationships.

#### Academic Abilities

McIlwee and Robinson found that “excellence in math and science was a primary factor propelling our female respondents toward engineering” (p. 24). This may sound obvious, until we learn from the same authors that the primary factor orienting men towards engineering was tinkering experience. Men’s maths and science abilities ranked only third amongst the factors influencing them to choose engineering, with the second most important factor being encouragement by their fathers or other family members. Beder (1989) reports similar findings in an Australian context.

#### Pragmatic career choice

The next most powerful influence on women’s choice to study engineering found by McIlwee and Robinson, was that engineering was a good career choice. It was well-paid, and there were plenty of jobs. Although the same could be said of medicine (an alternative career for students who are good at maths and science), those women who selected engineering did so because the training period was considerably shorter. These women perceived engineering as having an additional advantage over medicine as a career. Looking ahead to when they would become mothers, they thought that because engineering usually involved regular hours, it would be an easier career to combine with motherhood than medicine.

#### Personal relationships

A number of authors have discussed the influence of family and friends on women’s choice of SET degree study (Carter and Kirkup 1990, McIlwee and Robinson 1992, Geppert 1995). McIlwee and Robinson found that family relationships strongly influenced both men and women to become engineers, particularly if their fathers were engineers. Thirty-five percent of the women engineers in their sample had fathers who were engineers, compared with 27% of the men. These authors also found that women who became engineers were more influenced than their male counterparts by teachers, careers advisors and friends.

#### **Negative influences on orientation to SET**

McIlwee and Robinson did not find much evidence, among their female interviewees, of *interest* in working in engineering; on the contrary they found that most women drifted into this field following careers advice based on recognition of their maths and science abilities. This is surprising in view of DETYA’s consistent findings that “... intrinsic interest in a field of study ...” is one of the main reasons for students choosing to undertake tertiary study (DETYA 2000a).

Sharon Beder has explored how and why engineering is unattractive to many women (Beder, 1989). She finds that the

“... obsession with the technical, the mathematical and the scientific and an almost complete neglect of the social, political and environmental issues ... that shape engineering practice in the real world ...”

in most Australian engineering degree courses discourages

“... students with broader interests, a different range of talents ...; those who want to work with people rather than machines and numbers, those who care about social relations. Too often it is the female students who are put off” (p. 173).

From her industry experience, Beder challenges the necessity for the heavy emphasis on maths and science in engineering degree courses, and the resulting barriers imposed on entry to these courses by requirements for good grades in these subjects. She points out that if women lack the usual entry qualifications in these disciplines, this should not be automatically interpreted as an indication of lack of ability, but may well have arisen from a lack of interest and motivation in studying these subjects, a result of the different socialisation processes experienced by boys and girls. Lack of interest, therefore, can lead to another barrier: lack of entry qualifications.

Lack of interest in IT is also now showing as a negative influence on computer science study amongst certain groups of young women. IT is apparently acquiring such a 'nerd' image that in Australia there is a fear that soon "... young female native-English speaking computer programmers will be less prevalent than <ditto> engineers" (Edwards, 1999). Other factors discouraging Anglo-Australian young women from taking up computer science are ignorance of the variety of careers available, and, in mixed sex schools, male dominance of computer labs. A UTS investigation found that nearly all its local female IT students were drawn from girls', not mixed, schools (Maslen 1996, Edwards 1999).

A study by Le Grange, Rochford, and Sass (1996) in South Africa provides another perspective on gender differences in interests in SET. This study found that male and female engineering students assigned different priorities to fifteen global science-technology-society problems (though both groups agreed that the two problems with highest priority were population growth, and fresh water supplies).

It was considerations such as these that influenced the authors of the Australian *National Position Paper for Women in Engineering for the Review of Engineering Education* (Roberts and Lewis 1995) to analyse the characteristics of engineering education as:

Systems and problems that involve uncertainty or the complexity associated with human systems are often ignored or simplified by narrowing the problem definition. Methodologies and disciplines that attempt to incorporate the complexities of human systems are seen as "soft" and devalued in comparison. The arbitrary drawing of boundaries to define problems and the prioritization of values used for decision making (usually technical and economic rather than social and environmental) again are invisible within the culture. Decisions are regarded as objective, rather than being based on the personal or organisational values that they really represent. (p. 9).

Overall, the advice to recruiters to SET courses is to be aware of these negative influences on certain groups of equity and diversity students. Chief amongst these seems to be the lack of interest arising from an image of SET study as being objective and reductionist, devoid of applications which improve the human condition. To remove this barrier, it is first necessary to change the curriculum to give greater prominence to the social and environmental concerns of engineers, and then to market this emphasis more effectively. Secondly, opportunities need to be available for good students to qualify as engineers even if their motivation to do so develops relatively late in their scholastic careers.

### **Implications**

The findings about both the positive and negative influences on equity and diversity students' choice of SET tertiary education have important implications for a university hoping to attract these groups of students to SET programs. Successful marketing requires firstly having a product which is attractive to consumers, and secondly informing those already interested that you are offering this product, and persuading others that this is something they want too.

Firstly, therefore, universities must ensure that their SET programs are of interest to potential students from the social and cultural groups they want to attract. Some of the authors quoted above have advice about this. Roberts and Lewis (1995) advise that an engineering curriculum should:

- ... develop an appreciation of role and contribution of other disciplines to engineering [and]
  - use multi-disciplinary approaches which show the applications of the technology in other disciplines to provide social context for theory
  - develop the ability to use a range of research methodologies: such as action research and a systems approach to develop and evaluate designs for community needs and long term impact. (p. 27).

Le Grange *et al* (1996) concluded that there is a need for “... modern curricula with interdisciplinary approaches in both engineering and commerce ...” (p. 18), and probably also for including aspects of the humanities in engineering.

After ensuring that the SET programs on offer are appropriate and attractive to the target groups, the next task is to market these, bearing in mind what we have learned from the literature: for example that women who take up SET study tend to do so because they have excelled at maths and science, think it leads to well-paid work with regular hours, and because they have been advised by family and careers counsellors to do so.

## **Retention and success**

### **Introduction**

In this section we consider the literature relating to the retention and success of equity and diversity students in the SET disciplines. Much of the primary research in this area has been undertaken in the school sector, with the findings having been widely accepted as also being applicable to tertiary education. The discussion here is, initially anyway, largely based on a retrospective lecture given by an influential American mathematics educator, Elizabeth Fennema (1993), in which she outlined the developments of the previous twenty years in her own field. The discussion in this chapter uses this lecture as a framework for two reasons in addition to the widespread applications of Fennema’s findings to tertiary education. The first is that her exposition of the developments in her particular discipline clearly identifies the main chronological trends and influences which have occurred in the wider field spanning all SET education. The second is that everything she says about mathematics has also been shown to be applicable to the disciplines of engineering and physics, and much of it to computer science as well (Byrne 1994). The contrasting gender balance usually found in biology and other life science courses (illustrated in Appendix A) have in some respects positioned these disciplines differently in ‘equity’ debates in the past. As the complexity of the underlying gender and other equity and diversity issues in SET has been revealed, however, the life sciences have increasingly been drawn into this debate (Keller 1985, Webb 1995), and in the overview which follows this group of sciences are therefore also included where relevant.

### **Gender differences in attitudes to learning SET**

In a series of publications spanning two decades, Fennema and colleagues made four significant advances into the issues surrounding girls’ achievement in mathematics. The first two of these are recorded in a series of publications known as the Fennema-Sherman studies (Fennema 1974, Fennema and Sherman 1977, 1978, Sherman and Fennema 1977). This series firstly established empirically that, at that time, there were differences between boys’ and girls’ participation, learning, and achievement, in mathematics, and these differences increased with adolescence. The

authors then attempted to identify the causes of these differences, by looking for ‘affective’ or ‘attitudinal’ variables. The two variables identified as significant were (i) perceptions of the usefulness of mathematics, and (ii) students’ levels of confidence in learning mathematics. In both cases males were found to be more positive than females. These findings formed the basis of many strategies of the period designed to increase the participation of girls and women in mathematics and related disciplines, by demonstrating the usefulness and relevance of science and engineering, and building girls’ confidence in these disciplines (J. Harding 1996).

### **Cognitive factors**

Fennema’s third advance was into the cognitive domain, defined by Brown and Borko (1992) as “... the contents of the human mind (knowledge, beliefs) and mental processes in which people engage ...”. Educational research into cognitive factors usually focuses on how students’ progress is affected by their previous training and the ways in which they engage with new learning. In addition to this focus on *students’* cognitive processes, there is also an area of research which examines how the knowledge and beliefs of *teachers* affect student learning (Ballard and Clanchy 1997, Biggs in press).

#### *The role of learning support*

To many higher education teachers the most obvious differences in cognitive factors between equity and diversity students, and those from the numerically dominant social and cultural groups, are the gaps in knowledge and skills arising from a different preparation for higher education. International students and students from low SES<sup>5</sup> backgrounds may have problems with writing in ‘standard’ English, or be less computer literate than those educated in the more advantaged Australian high schools. Women students may be unfamiliar with the names and uses of various electronic or mechanical components. The usual first line of action therefore, in accommodating equity and diversity students, is the provision of ‘remedial’ help, or to use a more modern term: ‘learning support’. These terms are applied to systems of extra academic tuition made available to individuals or small groups of students identified as having a need. For students who accept that they have a need, and who are sufficiently motivated to devote time outside their regular classes to additional classes, these services are indeed invaluable.

Research has shown however that student support of this nature is not necessarily used by the students who need it, either because they are not aware of their need or because they do not wish to be publicly identified as ‘deficient’ or ‘disadvantaged’ (McLaine 1991). It is now regarded as more equitable, as well as more effective, to provide for students with gaps in their prior knowledge and skills in more inclusive ways. For example, introductory classes in computing, or familiarisation with engineering devices or components, are provided as part of the regular curriculum (Kramer-Koehler, Tooney, and Beke 1995). Another device is to encourage students to set up their own ‘self-help’ groups. One such system is known as ‘supplemental instruction’ which, despite the name, is not remedial, since it is open to all students, not only those identified as being in need. In this system, students form their own support groups, which are led by specially trained students from more senior years. These groups aim to integrate what-to-learn with how-to-learn, practising for example, note taking, questioning and revision techniques (Martin and Arendale, 1994). ‘Peer-mentoring’ (Nafalski, Berk and Cropley, 2000), and ‘Peer Assisted Learning’ are similar systems.

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<sup>5</sup> socio-economic status

### Gender differences in cognitive processes

In a longitudinal study over three years, Fennema and Tartre (1985) explored gender differences in cognitive processes. Their main finding confirmed earlier work by others which suggested that males and females possess different spatial skills: males generally finding it easier than females to visualise three-dimensional objects, particularly when motion is involved.

In a wider context, the much-quoted book *Women's Ways of Knowing: The Development of Self, Voice and Mind* (Belenky, Clinchy, Goldberger and Tarule, 1986) is regarded as one of the fundamental texts in this debate as to whether women learn in different ways from men. One of Belenky *et al*'s main findings is that women have a need for 'connected' knowing. For example, women need to "... understand the relationship of the particular problem or experiment to the broader context of the bigger problem of which this solution may be a part" (Rosser 1995, p.6). In another study, Fennema and colleagues (Fennema, Peterson, Carpenter and Lubinski 1990) found that "... teachers attributed the boys' successes more to ability and girls' successes more to effort ..." (Fennema 1993).

These findings have been influential in advocating the use of a *range* of teaching and assessment methods. Although the gender difference in spatial skills is relatively minor across the whole spectrum of learning, it is a reminder that female and other equity and diversity students may be disadvantaged by too heavy reliance on a narrow range of techniques in teaching and assessment.

### **Classroom organisation – inclusive curriculum (1)**

Fennema's final significant contribution to this field was to explore the impact of teachers and classroom organisation on the learning of girls (Fennema and Leder 1990). Perhaps the most influential finding of this phase is that teachers (even those who consciously tried to teach 'equitably') were shown by video recordings of their classes to give more of their time to male than to female students. Findings such as these have been used to urge teachers to be more 'inclusive', in the sense of ensuring that no groups of their students were excluded from any classroom or laboratory activity (University of Adelaide 1991).

An extension of this approach is to examine the extent to which all components of the curriculum are rooted in the Australian Anglo-Celtic tradition, and consider how to draw "... the content, teaching methodology and organisational patterns of subjects from a wide cultural base." (Martens 1994, p. 6).

These interpretations of 'inclusivity', while still advocated and acted upon, are now however regarded as incomplete, and we give more modern interpretations below.

### **Learning styles – inclusive curriculum (2)**

Most of the research quoted above has now been subsumed into the 'learning styles' debate. The term 'learning styles' is used to describe how individuals and members of different cultural groups prefer to receive, process and present information and ideas. Learning styles are affected by dispositional factors (in teaching staff as well as students), and cognitive factors. The existence of gender and cultural differences in learning styles has been well established (Knowles 1990, Moxham and Roberts 1995, University of Western Australia 1996, Ballard and Clanchy 1997), and the implications for effective teaching and learning are significant. Byrne (1994), Rosser (1995), Moxham and Roberts (1995), and Harding (1996), for example, all find some or all of the following characteristics in women's SET learning styles: women prefer to participate verbally; and to be more self-disclosing than males; they prefer collaboration to competition; and for all these reasons they prefer to work in groups. Ballard and Clanchy (1997) discuss how cultural

differences in *teaching* styles strongly influence the *learning* styles of students educated in different countries.

Underlying all the work quoted above has been the assumption that there is a fixed overall body of scientific knowledge, from which teachers make selections of what is to be taught to their classes. Any problems which students have with learning SET arise either because they lack the necessary motivation or skills for effective learning, or because their teachers lack understanding of what might be described as the ‘dynamics’ of equitable teaching. The implication is that having identified these ‘shortcomings’ in students and teachers, strategies can be devised to address or circumvent these attitudes and deficiencies, and thus enable students to engage more effectively with the given curriculum content. Many appropriate ‘interventionist’<sup>6</sup> strategies have been devised and employed which have indeed resulted in an increase in girls’ and womens’ confidence in SET study and perception of its usefulness (Fennema 1993, Kreinberg and Lewis 1996).

Attention to socially and culturally-formed learning styles are also now regarded part of an inclusive curriculum. All students should be encouraged to be aware of their own preferred learning styles for particular kinds of tasks, and also to develop a range of learning styles in order to improve their skills generally.

### **Challenging the nature of science – inclusive curriculum (3)**

A number of scholars however, contend that there is another dimension to the whole field of the participation of women and other non-traditional students (and hence power-relationships) in science and technology, and that is the *nature* of scientific scholarship.

In their work critiquing the body of gender and science research, Johnstone and Dunne (1996) use the Habermas (1972) framework of three ‘knowledge-constitutive interests’: technical, practical, and emancipatory. The ‘technical’ interest in knowledge arises from the

... need for control and prediction of the environment. What counts as knowledge is seen as generated through observation and verified through experimentation. This view conveys an image of an external, objective body of knowledge, where the territory and procedures for investigation are demarcated strongly. There is a strong connection between the technical interest, the scientific tradition and positivist philosophy. (Johnstone and Dunne 1996, p.53).

Popper (1968) and Kuhn (1970) challenged the traditional confidence in this ‘positivist’ (objective, logical and absolute) nature of science. Their challenges resulted in the recognition that “... knowledge is a human construction and that the processes by which it is legitimated are political, whether that knowledge is scientific, aesthetic or moral” (Johnstone and Dunne 1996, p.54).

This change of perspective constitutes the ‘practical’ interest in knowledge, the recognition that “knowledge is ... socially constructed through interpretation and as verified through consensus.” (Johnstone and Dunne 1996, p.54). Research methods in this ‘practical’ school are usually qualitative (sometimes described as ‘interpretative’), employing devices such as interviews, observation, and case studies. This school of research has been criticised on two grounds: (i) that it “... denies the involvement, the contaminating and disturbing presence, of the researcher ... [yet] such research is presented to us in such a way as to deny this, to suggest that what we have instead is ‘truth’ ...” (Stanley and Wise 1983, p.160); and (ii) that it “... produces and reproduces

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<sup>6</sup> a self-explanatory term used extensively in US literature

a differentiated epistemological status between the ‘expert’ researcher and the research participants ...” (Johnstone and Dunne 1996, p.55). In other words, there is a hierarchy of those involved in the research, with the researcher (alone amongst those involved in the research), despite his or her ‘contaminating and disturbing presence’ regarded as the expert, the one who is ‘legitimated’ to report and interpret the research.

Johnstone and Dunne describe the third of the ‘knowledge-constitutive interests’: the ‘emancipatory’ interest in knowledge development, as one in which “... knowledge is regarded as socially constructed but *the politics of its construction and legitimation* are a central and continual concern ...” (Johnstone and Dunne 1996, p.54, authors’ italics). In the context of gender and science, the emancipatory interest raises questions about the interaction between gender and power in our society.

Feminist scientists such as Bleier (1984), S. Harding (1991), Wertheim (1997), espousing the ‘practical’ and ‘emancipatory’ interests outlined above, question the validity of sciences developed and interpreted almost exclusively by white men. Scientists of this school argue that science which develops from these origins is necessarily incomplete (Rosser 1995). These sorts of questions raised by feminist scientists are now also being asked in cross-cultural contexts (S. Harding 1998). It is suggested for example that some critical environmental issues have been neglected because white male scientists with a predominantly industrial perspective have until now determined the priorities for scientific enquiry (and allocated the requisite funding). Scientific research would have taken different directions, it is argued, if women, (or indigenous people, or non-westerners), had been influential in these decisions (Webb 1995).

The questions raised above indicate that the concept of SET *knowledge construction*, as well as other aspects of what is usually regarded as the ‘content’ of an academic subject, and the methods of teaching and assessing it, is also challenged by gender and cultural research. Rosser (1995) provides an example of how women’s perspectives and expectations led to an advance of knowledge in primatology, in an area which had been overlooked by men. Female primatologists identified and analysed female-female interactions amongst primates, and these new observations led to substantial changes in theories of primate behaviour.

It is strongly argued by proponents of equity and diversity issues that SET curricula should expose questions such as: “... how issues of gender and ethnicity shape scientific norms, ideas, and practices; and to what depth such issues permeate the scientific enterprise” (Bianchini, Whitney, Breton, and Hilton-Browne, 1999).

Another standpoint on the inclusive curriculum therefore requires us to challenge the way that SET knowledge has been constructed, from gender and cross-cultural perspectives, and how these processes have affected SET, as well as power relationships in society.

## **Diversity**

### **Introduction**

Gordon (1999) claims that, in both the corporate and the educational sectors: “on a worldwide level diversity is growing to become the equivalent of the ‘quality’ issue of the 80’s” (p. 300). In this section we address the advantages arising for SET education and professions from the greater range of perspectives and values contributed to the learning environment, and to business and industry, by students and professionals from diverse backgrounds.

Some significant research about the benefits of student and staff diversity in higher education is appearing in the US (much of it available from the *Diversity Web* website<sup>7</sup>), but there seems to be little so far in Australia, especially in the SET disciplines.

There are at least three reasons for universities to encourage diversity amongst their students and staff. The first is that educational quality depends on diversity. We all learn more, and more effectively, by being stretched and challenged; and the different perspectives, objectives and experiences which can be contributed to a class by students from diverse backgrounds can contribute to this process. Secondly, such experiences can also prepare students for employment which increasingly in the twenty-first century will require them to work comfortably and effectively with colleagues and clients of any race, class or ethnic origin, and in cultures other than their own. The third reason for encouraging diversity is to increase the supply of members of 'minority' groups in leadership roles in mainstream society, essential for the health of a democracy in which these groups are represented.

### **Educational Quality**

Most academics agree that higher education should encourage students to challenge, question, analyse, and interrogate; and also provide them with the skills to do so. Only by using these techniques can knowledge advance, and applications which benefit humankind develop. The development of these essential attitudes and skills can be greatly enhanced when the student community is socially and culturally mixed.

Patricia Gurin, Professor of Psychology and Women's Studies at the University of Michigan describes the advantages thus:

A university composed of racially and ethnically diverse students (what I refer to as "structural diversity"), a curriculum that deals explicitly with social and cultural diversity, and interaction with diverse peers produce a learning environment that fosters conscious, effortful, deep thinking. For most of our students, the social diversity of the University of Michigan creates the discrepancy, discontinuity, and disequilibrium that are so important for producing the mode of thought educators must demand from their students. Vast numbers of white students (about 92 percent) and about half (52 percent) of the African American students come to the University of Michigan from segregated backgrounds. ... Thus, for most of our students, Michigan's social diversity is

- new and unfamiliar;
- discrepant from their pre-college social experiences;
- a source of multiple and different perspectives; and
- likely to produce contradictory expectations.

These are the very features of an environment that research has determined will foster active, conscious, effortful thinking -- the kind of thinking needed for learning in institutions of higher education. (Gurin 2001).

Denise Bradley, Vice Chancellor of the University of South Australia, describes such a learning environment as 'intercultural' and has said:

... people (students and staff) learn to understand and work with 'otherness', learning to observe, compare, analyse, explain and engage with 'other' ideas and people. This requires understanding of other systems of belief, ideologies, languages and communication ... . An intercultural view of learning is not only a matter of content; it also includes a pedagogy of 'otherness'. (Bradley 1997).

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<sup>7</sup> at <http://www.diversityweb.org/Leadersguide/DREI/bod.html>

### **Supporting professional practice**

Diversity is currently an aim in many businesses, with the lead again coming from the US. Business and industry are always seeking new products and processes. It is argued that a diverse, as opposed to a homogeneous, workforce, is more likely to be creative and innovative, as well as more proactive in identifying and developing new markets (Bowen, Bok and Burkhart, 1999, Gordon 1999, Gilmartin 1999, NCGCD 2000).

How well an enterprise works – how productive and successful it is in a highly competitive global economy – depends on whether it has the best people and people who are comfortable working across lines of race, class, religion, and background. ... Diversity is a business imperative because it affects competitiveness. (Bowen *et al* 1999, p. 141).

Hewlett Packard views diversity as a key business issue which will return benefits through lower staff turnover, a more creative workforce, better products and services and better customer relations. (Gordon 1999, p. 303).

Universities which encourage intercultural and international approaches to engineering and technological issues and problems are preparing students to work in globally competitive markets, and alongside colleagues with diverse backgrounds.

### **Contributing to mainstream society**

The research reported by Bowen *et al* (1999) found that ‘minority’ graduates have not only been successful professionally, but are entering positions of leadership of all kinds. That report emphasises that business leaders support diversity not only for the benefits arising to business itself, but also because ultimately:

... corporations will not be healthy unless the society is healthy, and a healthy society in the twenty-first century will be one in which the most challenging, rewarding career possibilities are perceived to be, and truly are, open to all races and ethnic groups (p. 141).

Gurin undertook empirical research to explore the impact on society in general of graduates who had experienced a diverse learning environment. She found many positive effects:

White students who attended colleges with 25 percent or more minority enrollment, as contrasted to white students who attended colleges with very low minority enrollment, were much more likely to have diverse friendships after leaving college and to live in diverse neighborhoods and work in settings where co-workers were diverse. ...

... The results strongly support the central role of higher education in helping students to become active citizens and participants in a pluralistic democracy. Students who experienced diversity in classroom settings and in informal interactions showed the most engagement in various forms of citizenship, and the most engagement with people from different races/cultures. They were also the most likely to acknowledge that group differences are compatible with the interests of the broader community. (Gurin 2001).

The authors of this Report are well aware that many (academic and non-academic) scientists and engineers may challenge the notion that students in SET disciplines are being educated for responsible citizenship, as well as for professional practice in their fields. We note that the Task Force charged with advising the authors of the *Review of Engineering Education* (IEAust 1996), on ‘Interface with the Community’ for example, seems to have interpreted its brief as considering how the community can be ‘educated’ to improve the image of engineers and engineering, rather than how engineers can contribute to a ‘healthy’, democratic society, in which the issues and priorities concerning human rights, satisfaction of basic needs, and cultural development, are openly discussed; and decisions made democratically. We look forward to further debate on the role of SET education in achieving these aims.

**Inclusive curriculum (4)**

Yet another constituent of the inclusive curriculum is therefore provided by the ‘diversity’ perspective. Introducing students to the different attitudes, points of view and priorities of different social and cultural groups towards SET issues improves the quality of education for all groups by encouraging debate and analysis. This experience is also a firm foundation for working in a global economy. In addition, a socially and culturally mixed learning environment gives students the opportunity to develop intercultural cooperative working skills, and respect for colleagues from all backgrounds, which will be useful both in their professional lives and more generally, as citizens in a multi-cultural society.

**Chapter summary**

Early research on the access and success of equity and diversity students in SET study concentrated principally on (negative) ‘dispositional’ factors amongst female students, which prevented them from opting for SET tertiary education, for example perceptions that SET studies were not interesting, useful or relevant, or lack of confidence in being able to succeed in SET. From these early investigations, interest developed in gender differences in the cognitive domain; although some minor differences were identified, this field of exploration is now usually regarded as unproductive and of little use. A more promising area of exploration is how the beliefs and expectations of teachers in relation to students from different social and cultural groups affect the success of these students. A further development from these investigations has been to explore how classroom, laboratory, and even institutional organisation can affect the success of equity and diversity students. Most of these influences on learning can be combined under the headings ‘learning’ or ‘teaching’ styles. In the interests of assisting all students to reach their potential it is important to consider how differences in gender and cultural learning styles affect our students, as well as the influence of our own culturally-influenced teaching styles. Appropriate teaching and assessment strategies which accommodate a range of these styles should therefore be employed.

Approaching the issues from a different direction have been the challenges to the nature of science and scientific enquiry. Questions have been raised about how priorities for scientific research are determined, how the results are applied, and whether the objective methodology traditionally employed by (usually white, male) scientists is always optimal in the quest to advance human scientific knowledge.

Much of the content of this chapter to this point is summarised by Willis’s table below illustrating four perspectives of the ‘gender-equity’ curriculum. Willis argues that to achieve ‘gender-equity’, all of these perspectives must be employed. Her argument is also applicable to a curriculum aiming for ‘cultural-equity’.

	<b>The disadvantaged learner</b>	<b>The curriculum</b>	<b>Equity requires</b>	<b>Inclusivity and social justice is served by</b>
<b>1</b>	has a deficit which needs remediation	is innocent	Equal (the same) provision OR equal access	compensatory education to enable access. (This is usually prior to or alongside ‘the curriculum’ which remains unchanged)

2	has been discriminated against	is innocent in content (intent) but often guilty as provided	equal opportunity to learn the 'curriculum content' and to demonstrate learning	fair learning opportunities and assessment practices. (The learning opportunities include learning contexts, physical, social and intellectual environment, physical resources, teacher time)
3	has not been included	is guilty (albeit unintentionally) of causing disadvantage	equally appropriate curriculum	reconstruction of curriculum /construction of 'inclusive curriculum'
4	has been excluded	constructs disadvantage to maintain the status quo	equality of outcome by group	Anti sexist/anti racist education, teaching students about positioning, provide skills for social action

Willis (1998)

Other authors have categorised perceptions of an inclusive curriculum into (progressive) 'stages' or 'phases'. Two of these are given in Appendix C.

In recent years the 'equity' debate has widened into 'diversity'. While it is still necessary to ensure that students from disadvantaged backgrounds are helped to succeed in their studies (so long as this is done in inclusive ways), there are many educational benefits to be derived for *all* students from diversity amongst them. Firstly, the presence of differences of opinion, background, and expectations, in university classes provides a learning environment that encourages debate, the foundation of scholarship. Secondly, graduates from a diverse learning environment are able to take their place with ease in a diverse, or international, working environment. If, in addition, they have training in alternative approaches to professional issues and problems, they are valuable to employers operating in other cultures and physical environments. Finally, graduates who have been educated where diversity is valued, can contribute more effectively than those without this experience, to the maintenance and development of social justice and social harmony, as well as other aims of a democratic society.

## **Chapter 3: The Division's Equity and Diversity Student Profile**

In this Chapter, we examine the equity and diversity student profile for the DITEE in 2000, in order to identify those aspects in which the Division is particularly successful, or unsuccessful. The data presented in tabular and graphical form are the 2000 equity statistics for the 7 Schools in the Division ITEE (in percentages of the Schools' total Australian intake), against DETYA's 4 performance indicators (access, participation, retention, success). Proportions of international students in each School are also given.

In each table and graph, the three Engineering Schools are shown first, followed by the remaining four Schools (rather than Schools being ordered alphabetically, the usual University practice). The purpose of this rearrangement is to facilitate comparisons between the Schools, since with their common culture, they encounter similar problems in reaching their equity and diversity targets.

### ***Access and Participation***

In this section the seven equity groups are divided into 2 larger groups: Group 1 and Group 2. Group 1 comprises female, low SES, and rural and isolated students (aggregated), and Group 2 contains ATSI, disabled, and NESB students. They are grouped this way partly because it is easier to make comparisons in groups of 3 or 4 than groups of 7, and partly because the ranges of both the Access and the Participation rates for Group 1 (up to 50%) are significantly greater than for Group 2 (up to 12%). For graphical display purposes, all the data becomes more visible by using a larger vertical scale for graphs relating to the second group than for the first group.

Between each group comments on the main points arising from the data are provided.

**Access 2000 (percentages)**

*Group 1 Equity students*

	female	Low SES	Rural & isolated
AME	3.0	26.9	13.5
EIE	12.6	27.7	10.1
GMC	15.0	31.3	16.3
CIS	25.9	27.7	10.4
ERM	41.8	30.9	14.5
GPB	28.8	21.8	8.3
MAT	49.3	28.0	13.3

Table 1: Access of Australian equity students (Group 1) 2000, as percentage of all Australian students, Schools in DITEE

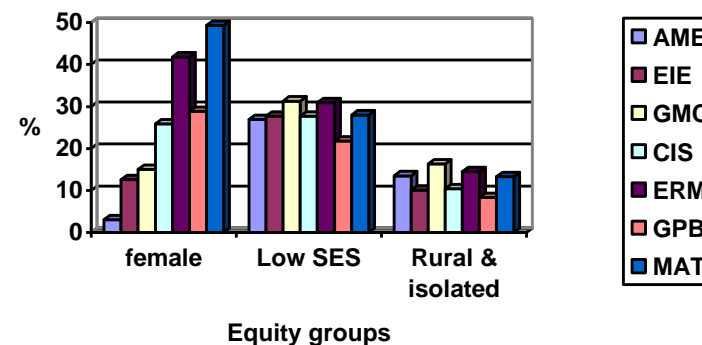


Figure 1: Access of Australian equity students (Group 1) 2000, as percentage of all Australian students, Schools in DITEE

*Access of female Australian students: Changes over time*

	1996	1997	1998	1999	2000
CIS	23.46	21.61	19.44	26.51	25.34
ERM	45.95	46.71	47.06	47.39	41.82
GPB	32.48	18.59	17.07	24.88	28.82
MAT	45.83	46.94	51.22	36.67	49.33
PES	11.7	10.71	9.9	11.11	
EGG	12.45	12.16	8.54	10.45	
AME					4.48
EIE					12.61
GMC					15.0

Table 2: Access of women in the Division ITEE 1996 – 2000 as a percent of all commencing domestic students in each School

Group2 equity students

	ATSIC	disabled	NESB
AME	0.0	0.0	11.9
EIE	0.0	2.9	6.3
GMC	0.0	2.5	3.8
CIS	0.2	3.0	6.0
ERM	1.8	0.0	0.6
GPB	0.0	2.9	2.9
MAT	1.3	1.3	8.0

Table 3: Access of Australian equity students (Group 2) 2000 as percentage of all Australian students, Schools in DITEE

**Participation rates 2000**

In this section a table and graph showing the *participation of international students* appears between those for the *participation of Groups 1 and 2 equity students*, because the range for international students lies between the ranges of the two Groups.

Group 1 equity students

	Female	Low SES	Rural & isolated
AME	5.2	23.9	16.0
EIE	11.3	29.7	11.6
GMC	16.1	20.2	23.5
CIS	21.2	26.6	9.4
ERM	46.2	27.0	17.2
GPB	20.4	16.6	8.8
MAT	45.1	34.2	10.3

Table 4: Participation of Australian equity students (Group 1) 2000, as percentage of all Australian students, Schools in Division IEE

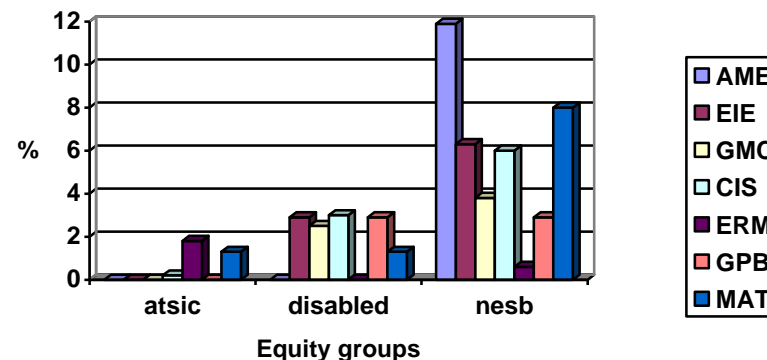


Figure 2: Access of Australian equity students (Group 2) 2000, as percentage of all Australian students, Schools in DITEE

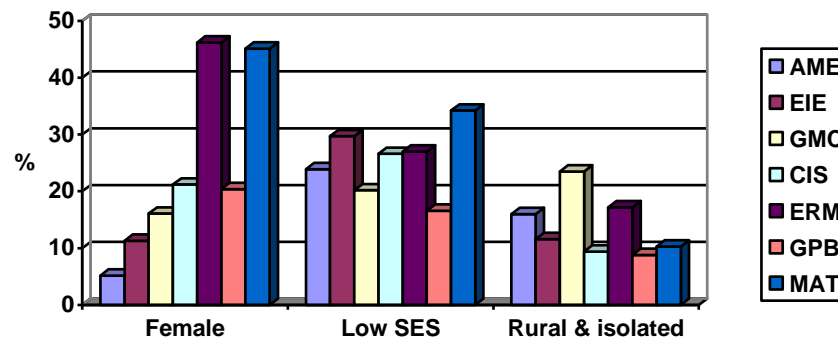


Figure 3: Participation of Australian equity students (Group 1) 2000, as percentage of all Australian students, Schools in DITEE

*Participation of female Australian students: Changes over time*

	1996	1997	1998	1999	2000
<b>CIS</b>	21.03	20.83	19.88	23.04	21.9
<b>ERM</b>	46.87	45.15	45.08	46.86	46.21
<b>GPB</b>	16.14	16.53	14.29	17.92	20.45
<b>MAT</b>	49.0	44.12	46.81	44.38	45.11
<b>PES</b>	10.53	10.71	10.32	11.82	
<b>EGG</b>	10.07	10.77	9.17	10.11	
<b>AME</b>					5.16
<b>EIE</b>					11.33
<b>GMC</b>					16.51

Table 5: Participation of women in DITEE 1996 – 2000 as a percent of all domestic students in each School

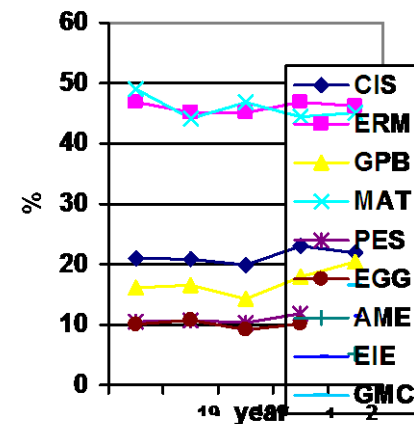


Figure 4: Participation of women in DITEE 1996 – 2000 as a percent of all domestic students in each School

*International students*

	International
<b>AME</b>	23.1
<b>EIE</b>	10.5
<b>GMC</b>	4.8
<b>CIS</b>	9.1
<b>ERM</b>	1.1
<b>GPB</b>	19.2
<b>MAT</b>	1.6

Table 6: Participation of International students 2000, as percentage of all students

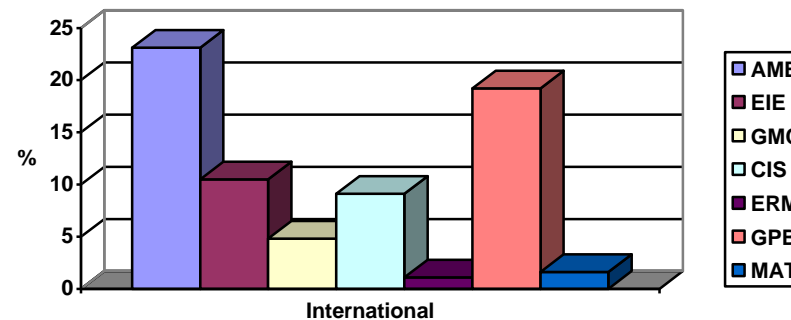


Figure 5: Participation of International students 2000, as percentage of all students

*Group 2 equity students*

	<b>ATSIC</b>	<b>disabled</b>	<b>NESB</b>
<b>AME</b>	0.0	2.3	7.5
<b>EIE</b>	0.0	3.1	9.7
<b>GMC</b>	0.0	2.7	4.7
<b>CIS</b>	0.2	3.0	6.8
<b>ERM</b>	1.6	1.3	0.4
<b>GPB</b>	0.2	2.7	3.1
<b>MAT</b>	0.5	2.2	6.5

Table 7: Participation of Australian equity students (Group 2) 2000, as percentage of all Australian students, Schools in DITEE

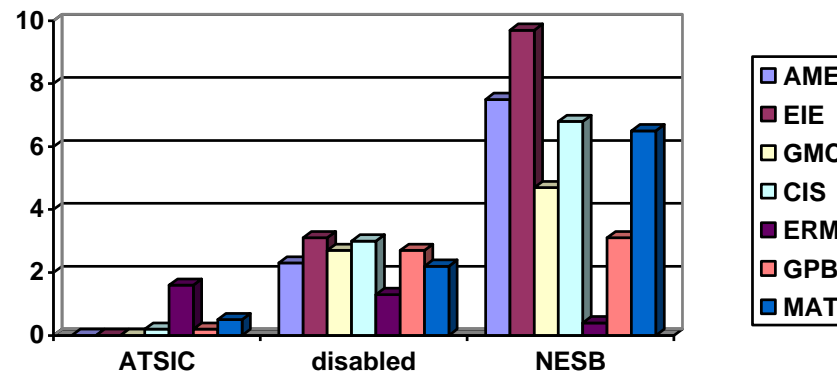


Figure 6: Participation of Australian equity students (Group 2) 2000, as percentage of all Australian students, Schools in DITEE

## Comments on Access and Participation Rates<sup>8</sup>

### Group 1 Equity students

#### *Female students*

- Access rates for women students fall into 3 distinct groups: MAT and ERM lead the Division with rates above 45%. CIS and GPB follow with rates between 25% and 30%. The Engineering Schools at this University, in common with their counterparts in most of the rest of the English-speaking world, have more difficulty than the other Schools in the Division in recruiting female students.
- The University's access rates for women in engineering are however improving, and currently our access rates are only just below the national average. This is particularly encouraging, since we do not offer degrees in chemical or environmental engineering, the disciplines which traditionally attract female students.
- It is encouraging too, that in 2000, for the first time since 1996, an engineering School (GMC) achieved and surpassed the University's long-term goal of 12% female engineering students (UniSA 1999b) with its access rate of 15%, and participation rate of 16.1%.
- EIE (with an access figure of 12.6%) also exceeded the University's target, but AME (with 3%) trails both the other Engineering Schools quite significantly.
- With access statistics lower than their participation statistics in both AME and GMC, there is a danger that the participation rates in these two Schools will fall in 2001.
- Looking at trends in female enrolments, it is difficult to identify any clear patterns across the Division, with CIS, ERM, and MAT hovering about their own means. GPB appears to be on an upward trend since 1998. Following the reorganisation of the Engineering Schools in 2000, it will be a few years before their individual trends will emerge, but there does appear to be an upward trend with GMC and EIE at least.

#### *Low SES students*

- The University overall recruited 24.3% low SES students in 2000. All the Schools in Division ITEE (except School GPB where students in this category represent only 21.8% of total intake) have exceeded the University's access rate for low SES students.

#### *Rural and isolated students*

- The University overall recruited 16.2% rural and isolated students. In the DITEE, only School GMC equalled the University's figure. The other Schools ranged from 8.3% (GPB) to 14.5% (ERM).

### International students

- Success in recruiting international students is wide-ranging in this Division. Schools AME and GPB lead the way with 23.1% and 19.2% respectively.
- The Schools ERM and MAT are the least successful with 1.1% and 1.6% respectively.
- The remaining Schools range from 4.8% to 10.5% respectively. (The University's average is 16.9%).

### Group 2 Equity students

#### *Aboriginal and Torres Strait Islander students*

- All the Schools in the Division are unsuccessful in recruiting Aboriginal and Torres Strait Islander students.
- There are no ATSI students in any of the Schools of Engineering, and no new ATSI students in 2000 in School GPB.

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<sup>8</sup> In this section percentages are of all Australian students, *except* the figures for international students, which are percentages of *total* (ie Australian plus international) students.

- In actual figures (percentages in brackets), the Schools CIS and MAT recruited 1 ATSI student each (0.2% and 1.3%) respectively in 2000, and the School ERM recruited 3 (1.8%).

*Disabled students*

- The University overall recruited 2.1% disabled students in 2000. Four of the Division's Schools exceeded this statistic: EIE (2.9%), GMC (2.5%), CIS (3%), and GPB (2.9%).
- Two Schools, AME and ERM, recruited no disabled students in 2000.

*NESB students*

- The University overall recruited 2.7% NESB students. With 1 exception (ERM, with 0.6%), all the DITEE Schools exceeded the University's overall statistic, four of them significantly. These 4 Schools are AME (11.9%), MAT (8%), EIE (6.3%), CIS (6%).

### Retention and Success

#### Retention: Group 1 Equity students

	female	Low SES	Rural	isolated
AME	100.0	87.5	92.3	100.0
EIE	77.6	79.4	87.5	100.0
GMC	91.7	85.5	82.9	68.8
CIS	68.1	75.1	76.8	89.5
ERM	84.9	90.6	88.1	100.0
GPB	67.7	52.2	61.1	66.7
MAT	85.1	72.4	72.7	75.0

Table 8: Retention rates of Australian equity students (Group 1) 2000, Schools in DITEE

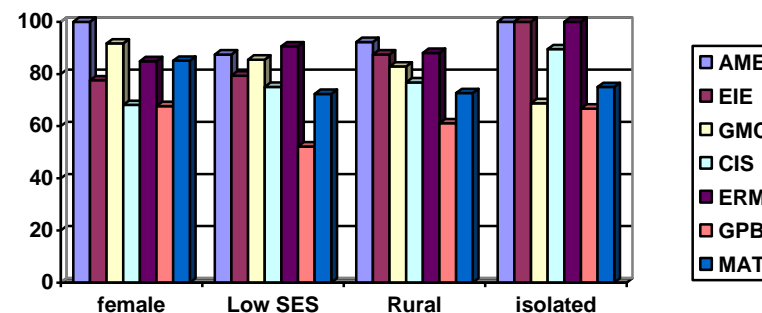


Figure 7: Retention rates of Australian equity students (Group 1) 2000, Schools in DITEE

#### Retention Group 2 Equity students

	ATSI	Disabled	NESB
AME	0.0	75.0	250.0
EIE	100.0	90.9	82.7
GMC	0.0	50.0	92.3
CIS	66.7	84.0	83.6
ERM	75.0	75.0	100.0
GPB	100.0	60.0	61.5
MAT	0.0	60.0	60.0

Table 9: Retention rates Australian equity students (Group 2) 2000, Schools in DITEE



Figure 8: Retention rates of Australian equity students (Group 2) 2000, Schools in DITEE

**Success: Group 1 Equity students**

	female	Low SES	Rural	isolated
AME	95.1	92.5	91.1	100.0
EIE	80.0	69.9	80.1	82.4
GMC	87.5	79.6	76.8	72.3
CIS	73.0	69.2	72.2	76.8
ERM	91.0	89.5	92.7	81.4
GPB	82.7	74.5	76.5	47.6
MAT	78.7	66.3	85.0	90.5

Table 10: Success rates of Australian equity students (Group 1) 2000, Schools in DITEE

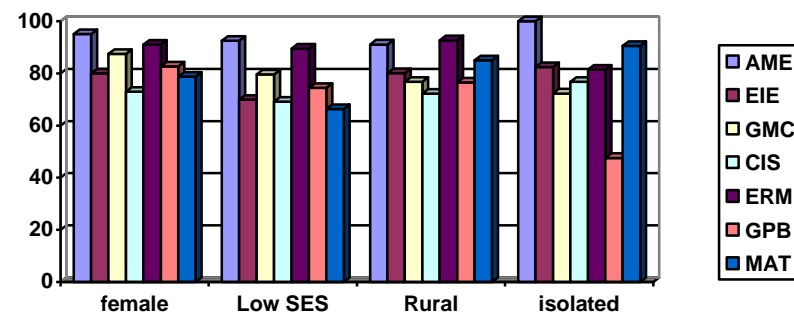


Figure 9: Success rates Australian equity students (Group 1) 2000, Schools in DITEE

**Success Group 2 Equity students**

	ATSIC	Disabled	NESB
AME	0.0	63.6	100.0
EIE	80.0	76.6	68.9
GMC	0.0	65.4	85.7
CIS	57.5	70.6	74.6
ERM	36.0	78.0	100.0
GPB	85.7	60.0	64.8
MAT	0.0	78.6	77.6

Table 11: Success rates Australian equity students (Group 2) 2000, Schools in DITEE

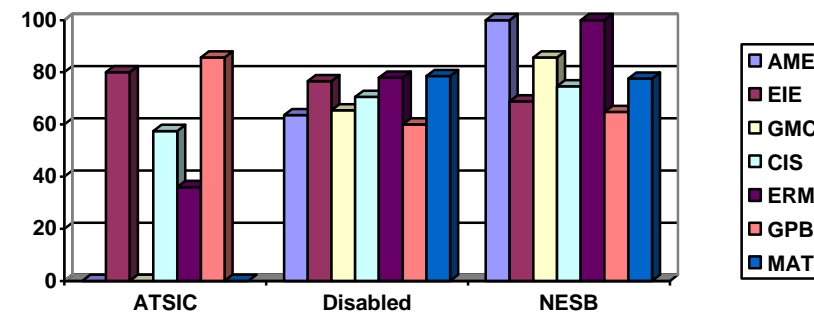


Figure 10: Success rates Australian equity students (Group 2) 2000, Schools in DITEE

## Comments on Retention and Success Rates

### Group 1 Equity students

#### *Female students*

- The University's overall retention rate for female students is 80.7%. AME, GMC, ERM and MAT have all exceeded this rate. EIE is close to it. The other two Schools are not as successful in retaining their female students.
- Only 3 of the Division's Schools exceed the University's success rate for women (86.8%). These 3 Schools are AME, GMC, and ERM. The success rates in the remaining 4 Schools range from 78.7% (MAT) to 82.7% (GPB).

#### *Low SES, and rural students*

- All 3 Engineering Schools, as well as ERM, exceed the University's rate of retention of low SES students, and rural students (79.2%, and 80.2% respectively). Again, it is CIS and GPB who do not reach this rate, plus, in these instances, MAT.
- Only 2 Schools exceed the University's overall success rate for low SES students (80.8%), and rural students (85.4%): AME (92.5%, 91.1%), and ERM (89.5%, 92.7%).
- MAT, with 85%, comes very close to the University's average success rate for rural students. The remaining Schools trail the University's rate.

#### *Isolated students*

- In the case of isolated students, the University's overall rate of retention is 82.2%. AME, EIE, CIS, and ERM, all exceed that rate, leaving GMC, GPB and MAT trailing it.
- The University's overall success rate for isolated students is 81.6%, a statistic which AME, EIE, ERM, and MAT all exceed.

### Group 2 Equity students

#### *ATSI students*

- Of those Schools which have any ATSI students (therefore excluding AME, GMC<sup>9</sup>), all Schools except MAT exceed the University's overall rate of retention of ATSI students which is 60.5%.
- All except ERM also exceed the University's success rate for ATSI students (53.2%).

#### *Disabled students*

- In general, the Division is less successful than the University as a whole in retaining its disabled students. All Schools except EIE and CIS have failed to reach the University's rate of 78.4%.
- None of the Division's Schools have as good a success rate for disabled students as the University as a whole.

#### *NESB students*

- AME, GMC, and ERM exceed the University's overall rate of 85.2% retention of NESB students. EIE and CIS (82.7% and 83.6% respectively) come close, but GPB and MAT (61.5% and 60% respectively) are not successful in this category.
- Three Schools exceed the University's overall success rate for NESB students (78.1%): AME, ERM (both with 100%), and GMC (85.7%). MAT comes close with 77.6%.

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<sup>9</sup> There is an anomaly here regarding School EIE, which is reported as having zero ATSI students in the Access and Participation data, but 2 in the Retention data).

## **Summary of the equity data analysis**

### **The Division ITEE has:**

#### **Success in recruiting low SES and NESB students, but less success in retaining and graduating them**

The Division is particularly successful in recruiting low SES, and (especially) NESB students. All Schools exceeded the University's Access rates for these groups except, in the case of low SES students, GPB, which slightly trailed the University, and, in the case of NESB students, ERM, which trailed the University rate rather more significantly.

Not all Schools however, are successful in retaining and graduating students from these two groups. CIS, GPB, and MAT are not as successful as the University as a whole in retaining low SES students. There is even less success in graduating students from this group, with only 2 Schools (AME and ERM) exceeding the University's average success rate. Regarding NESB students, only AME, GMC, and ERM retain and graduate students from this group at a rate above the University's average, with MAT's success rate approaching it.

#### **Moderate success in recruiting disabled students, but again less success in retaining and graduating them**

EIE, GMC, CIS and GPB all recruited disabled students at a rate above that of the University as a whole, but ERM and AME failed to recruit any. Only EIE and CIS however, are retaining their disabled students at a rate above the University's average, and no Schools are graduating their disabled students at a higher rate than the University as a whole.

#### **Wide range of performance in recruiting international students**

AME and GPB significantly outperform the University as a whole in terms of participation of international students. All the other Schools trail the University, significantly so in the case of ERM and MAT.

#### **Less success in recruiting rural and isolated students, retention and success rates variable**

With the exception of GMC, none of the Schools recruited rural and isolated students as successfully as the University as a whole. Two of the Schools however, (AME and ERM) are more successful than the University overall in retaining and graduating these two groups of students. GMC and EIE are more successful than the University overall in retaining rural students, but not as successful in graduating them. In addition to AME and ERM, CIS and EIE are also more successful than the University overall in retaining isolated students, and EIE and MAT in graduating them.

#### **Recruitment of female engineering students improving, steady for other Schools. Retention and success rates variable**

Two of the engineering Schools (EIE and GMC) have improved their Access and Participation rates for female students significantly in 2000. The other Schools (with the exception of AME, a new School without as yet a track record) are maintaining steady rates. Only CIS and GPB do not retain female students at or above the University's average rate, and these Schools together with EIE and MAT are not as successful as the University as a whole in graduating female students.

#### **Little success with recruitment of Aboriginal and Torres Strait Islander students. Retention and success better.**

There are no ATSI students at all in any of the 3 Engineering Schools. ATSI students are represented in the other Schools in numbers ranging from 1 to 7 (ERM has the 7). Of these,

all except MAT retain their ATSI students at a higher rate than the University overall, and all except ERM outperform the University in graduating ATSI students.

## Chapter 4: Access strategies

Institutions of Higher Education adopt a number of strategies designed to improve access to SET courses. Broadly, these strategies can be categorised as:

- recruitment and awareness programs: targeting schools and teachers
  - activities in the schools
  - activities on campus
  - short residential courses
- preparatory programs
- widening entry routes and procedures, and special admissions schemes
- developing new award programs designed to appeal to students from equity groups
- scholarships for targeted groups

(adapted from Ashenden, Milligan, and Clarke, 1997).

Before however, commenting on how this University and others implement the strategies which fall under the headings listed above, we step beyond this recognised framework to report an additional strategy adopted in Canada which led to the striking headline in an IEEE newsletter: *Canada doubles enrollments of women in engineering in a decade* (Frize 1999). Frize claims that at least part of this success was due to a Natural Sciences and Engineering Research Council of Canada (NSERC) Task Force recommending the creation of five new professorships across a range of SET disciplines, to be open to women only, and to be spread geographically across the nation. This recommendation has been achieved with the support of Canadian industry. A condition of these professors' appointments is that each must take responsibility locally and (in collaboration with the others) nationally, to move the women in SET agenda forward. The authors of this Report recommend this strategy to Australian universities.

Another device not mentioned in the list above, is to set up a Women in Engineering Unit, or appoint Women in Engineering Officers, with responsibility for coordinating initiatives to recruit and retain women engineering students. Between the late eighties and early nineties this strategy was adopted in several universities, including this one, and it is no coincidence that this was the period which saw the greatest rate of growth of women engineering students in Australia. Regrettably, however, as university funding has become tighter, most of these appointments have been discontinued, sometimes with the 'justification' that numbers of women students were not increasing sufficiently to justify the expense, without apparently considering that the cultural change required is a slow process.

RMIT, one of the most successful of Australian universities in recruiting women engineering students, has not only succeeded in retaining its Women in Engineering Unit over the long term, it has now widened its focus to all equity students and has been renamed the 'Equity Unit'. The following evidence demonstrates its success:

The Women in Engineering Unit at RMIT's Faculty of Engineering was established in 1986 when only 5% of its student population was female. ... Now, in the year 2000, over 17% of the faculty's student population is female (Wyrill 2000).

A proposal to re-establish a similar 'equity' position in DITEE at this University was discussed at several levels in 2000. Sadly, despite the evidence of the success of this strategy from RMIT and similar institutions, this proposal was eventually rejected because of the cost.

### ***Recruitment and Awareness Programs: Targeting Schools and Teachers***

There are two purposes in targeting schools and teachers. The first is to increase the pool of school students qualified to apply for university SET courses, and the second is to influence the more senior school students who are already studying appropriate subjects, to apply for SET courses at university. 'Equity' students in both categories are targeted either for ideological reasons of social justice, or because the under-representation of some groups of equity students in higher education SET courses renders these groups a promising pool of as-yet untapped talent.

The process of encouraging equity students to persist with SET subjects throughout their secondary education can begin any time before they choose the subjects they will specialise in in their final 2 years. Some 'access' initiatives consequently target primary school students with the aim of exciting them about science (Perkins 1990, Jarvis 1996, for example). Most however concentrate on encouraging Year 9 and 10 students to persist with SET subjects until high-school 'graduation'.

Strategies employed to encourage senior school students to apply for tertiary SET programs include talks and investigative activities by engineers, using marketing devices which are designed to appeal to particular groups of students, and collaborating with school staff to in order to encourage them to recommend SET courses to their students considering university studies.

I try to take women and minority engineers with me to the [school] presentations so they can be role models for the students. I can stand up and tell groups of students they can be engineers, but if all they see are white male engineers, then they grow up thinking all engineers look like that. When I take women engineering students or women and minority faculty members with me, the students see that engineers look just like them. It sets an example for them to follow. (Bottomley, quoted in Weston, 2000).

### **Existing University of South Australia SET strategies targeting schools and teachers**

#### ***University-wide Initiatives***

##### *Targeting schools and teachers*

In 2000 the University created a new position: an *Equity and Diversity Marketing Officer*, who "... is responsible for university-wide marketing activities to prospective students with equity characteristics; [and] providing marketing advice and support to divisions ..." (UniSA 1999b, p. 21). Responsibilities include liaison with key community groups such as TAFE staff, secondary schools and Indigenous groups.

##### *Short residential courses*

Each year since 1990, the University's Unaiapon School has run a two-week residential summer school for 30 'high flyer' Year 10 Indigenous students drawn from all over Australia. Since most Indigenous university enrolments are currently in the arts and social science disciplines, this program, the *Aboriginal Summer School in Technology and Science* (ASSETS) is designed to encourage interest amongst this group of students in studying science and technology at tertiary level. Until 2000 the DITEE has been only marginally involved in this program, but is playing a larger part from 2001.

ASSETS students work on projects which are designed to develop their awareness of the scope and limitations of science, develop skills in data collection, problem solving, communication and team work, as well as extending their awareness of the role of pan-Aboriginality.

### Division ITEE initiatives

The Division is developing a database of secondary schools with a high percentage of ATSI, NESB, rural and isolated populations, and intends to target them for visits and with promotional material.

#### *Activities in schools*

Divisional staff from all disciplines attend high school careers events, including girls' schools. GMC and AME in particular also encourage their own students to participate in these events, ensuring that when they do, there is a gender balance. Both of these Schools are also building strong relationships with individual high schools (for example through the Solar Car Project), and AME is focusing its attention on its local, 'disadvantaged' Northern high schools.

Divisional staff also attend careers events overseas.

#### *Activities on campus*

GMC has since 1998 organised a work experience program for Years 10 and 11 students. The first enrolments attributable to this program did not occur until 2000, and it is already evident that the program is successfully attracting students, of whom a significant proportion are female.

The ITR has recently initiated an innovative 'enrichment' program with its neighbouring high school: Endeavour College. Mathematically gifted students of the College are introduced to the academic disciplines represented in the ITR through a 'discovery' program, involving mathematical modelling, use of MATLAB software, and hands-on experience with electronic components. Equity objectives are incorporated into this program by imposing the condition that there must be an equal gender balance in the group of students selected to participate.

### **Initiatives in other universities**

#### Targeting schools and teachers

RMIT holds an annual Engineering Awareness Program (EAP) for girls in the middle years of the secondary system, with spectacular success. This is a 2-day program in which female RMIT engineering graduates now working in industry describe their working life, and lead discussions. Over the last 4 years, 40% – 80% of the school students taking part in an EAP have enrolled in engineering courses. Not only is this success impressive, RMIT also found that at one school participating in the EAP, 40% of the students who were *not* able to attend because it was full up, also enrolled for engineering courses. RMIT also sends female engineers as speakers to schools, and holds an annual Open Day.

The Faculty of Science at *Adelaide University* has set up a partnership with Underdale High School, which recruits from an area in which "... tertiary study is not an expectation" (Adelaidean, 2000). Acting on the advice of the school principal that "A lack of confidence rather than ability keeps many students out of higher learning", the partnership operates student and staff exchanges, so that school students can experience university life, and university staff can understand the differences between high school and university teaching and learning practices.

#### Short residential courses

The *University of Southern Queensland* (USQ) is one of many universities using short residential courses for targeted groups as a recruitment exercise. USQ provides five-day annual "Girls in Maths and Sciences Summer Schools" for about 100 Year 10 girls, who work on projects and learn about working as scientists and engineers from SET practitioners. USQ is also applying its experience in this field to a promising longitudinal study of the factors which influence girls' choices in studying maths and science in Years 11 and 12 (AaeE, 2000).

### ***Preparatory Programs***

Preparatory programs are pre-degree-study programs designed for students who lack the academic background required for entry to SET undergraduate programs. They are often designated as 'access' or 'bridging' programs, lasting at least one semester, and aim to bring students to the required standard in science studies at an accelerated rate, using teaching methods which are particularly appropriate to the age and experience of the students involved.

#### **Existing University of South Australia preparatory SET programs**

##### *Division ITEE initiatives*

The Division's *Applied Science and Engineering Bridging Program* has been offered since the early nineties. This program is designed for students who wish to join science or engineering degree courses but lack the requisite qualifications of Maths 2 and Physics in their SACE. Students may follow the bridging program full-time, part-time, or externally in semester 1, and externally in semester 2. If they are successful they may proceed directly to a degree course.

The Division also offers a *Bridging Program in Information Technology*, for students who have not studied maths beyond Year 10. Students who are successful on this program may proceed into a wide range of information-technology-related undergraduate programs.

The AISU offers a *Conservation and Site Management Bridging Course*, specifically for Aboriginal and Islander students. This one year, full-time program prepares students to enter a number of undergraduate programs in the School of ERM.

The ITR introduced a new type of access program in 2001. Known as *SACE in Space*, this program provides 18-month traineeships in the ITR for Year 11 students from disadvantaged schools, who are studying maths and physics. The students attend the Institute for one day a week in term-time and also work there in their holidays. Satisfactory performance in this training will qualify as SACE 'free choice' subjects. Students who also pass Stage 2 Maths and Physics, and the other subjects required, will be guaranteed entry to any of the engineering or science courses offered in the Division ITEE.

### ***Widening entry routes***

Widening entry routes is a strategy designed to remove some of the 'institutional' barriers to the entry by equity and diversity students to higher education, such as keeping strictly to standard selection procedures based on exam scores, even though some promising students may, through poor teaching, health problems, or an economic necessity, have to leave school early, or have otherwise had limited opportunities to develop their potential in the expected ways.

#### **Existing University of South Australia widening entry schemes**

##### *University-wide Initiatives*

###### *Special admissions schemes*

The University admits educationally-disadvantaged students to all disciplines under a special admissions scheme known as *USANET*. This scheme is open to students at nominated disadvantaged, and rural, schools; adult re-entry colleges; and TAFEs (UniSA 1999a). Between 1998 and 2000, the total number of students entering the University through USANET increased by 168%. Success rates of most groups of equity students admitted through USANET are exceeding state and national rates (Bradley, 2000).

The University also encourages TAFE entry and credit transfer, as well as other entry routes which do not depend on TER scores.

### ***New Award Programs***

To address the issue of women and students from some other equity and diversity groups finding science dull and irrelevant when presented in the traditional reductionist way, many universities are devising new award programs which emphasise the relational and interdependent aspects of science with other disciplines, for example: Engineering and Business.

Another way of making tertiary study more accessible, particularly for students who are geographically isolated, or who cannot afford to forego earnings to undertake full-time study, is to provide 'distance', sometimes called 'external', programs.

### **New, targeted, SET award programs**

#### *University - wide Initiatives*

The University has an established history in distance-learning, having had 'telelearning centres' for several years. Recently the accessibility of its external programs has been advanced even further by the introduction of 'UniSAnet', the University's electronic on-line teaching environment.

#### *Division ITEE initiatives*

Over the last few years several Schools in the Division have introduced double degrees, in collaboration with Schools from other Divisions; for example double degrees in Engineering with Environmental Management, Arts (International Studies), and Business. These double degrees are already attracting higher proportions of female students than the single degree programs (EIE 1999, UniSA 2000).

### ***Scholarships***

Over the last decade university study in Australia has become progressively more expensive, and therefore less accessible to students from low income groups, or who have already acquired responsibility for a family. Scholarships therefore can make it possible for financially disadvantaged individuals to study for a degree.

### **University of South Australia scholarships for SET students**

#### *University-wide Initiatives*

##### *Equity scholarships*

From 1997 – 1999 DETYA financed merit scholarships in individual universities to encourage the participation of students from the nominated equity groups. Regrettably, this scheme was terminated in 1999 after only three years of operation, on the grounds that it had failed to reach its objectives (DETYA 2000b). In this University the scheme operated by sending an application form to all students offered an undergraduate place, and then ranking the applications received according to equity criteria. In 1999, scholarships were awarded to 66 of the 914 applicants, with all equity groups being represented among the recipients, most of whom were members of several equity groups (UniSA 1999b).

In 2000 the Chancellor's Development Office launched a Scholarships Appeal to provide opportunities and practical support for students who are disadvantaged by financial circumstances, or by location. Funds have been received so far to finance scholarships of \$3000 each year for selected South Australian residents who have lived in this State outside

the metropolitan area for at least five years, and whose total family income is less than \$30,000 per annum (Klingberg 2000).

#### *Division ITEE initiatives*

In conjunction with industry, the Division offers scholarships that are open to female students only. These include the Sylvia Birdseye scholarship (supported by Transport SA, and offered in civil engineering), the Henry Walker Group scholarship (offered in civil, mining, and metallurgical engineering), the Hypatia scholarships (supported by DSTO and offered in maths) and equity scholarships for postgraduate study.

#### **Initiatives in other universities**

A New York tertiary institution called '*Cooper Union for the Advancement of Science and Art*', sees scholarships as the key to recruiting 'minority' (in their case African American, Hispanic, and American Indian) students to engineering courses. The process starts with raising the money – by approaching industry and alumni. Once there are sufficient funds, promising students in inner-city high schools are invited to workshops which are designed to exercise thinking skills, creativity, and motivation. Students are selected for scholarships on the basis of their workshop performance, followed by an interview. In order to ensure as far as possible that the selected students will complete the course, and succeed, they are then required to attend an intensive summer school to bring them up to the academic standard of the other commencing students (Hannon, 2000).

#### **Chapter summary and conclusions**

Strategies adopted by most universities to widen access include marketing approaches targeted to equity and diversity students; providing academic programs designed to be of particular interest to these groups; widening admissions requirements; and providing scholarships. Special 'women in engineering' units, common a decade ago, have now largely disappeared, despite the evidence (from RMIT for example, one of the most successful in recruiting female engineering students) that they can be very successful given a sufficient length of life.

Collaborative access initiatives between universities are unusual, and Canada's success in establishing a network of women-only Chairs in engineering in five Canadian universities, supported by industry, is therefore particularly noteworthy. This relevance of this achievement to 'access' initiatives arises from the claim that this development was partially responsible for Canada doubling its number of women engineering students in a decade.

Comparing the University of South Australia's access initiatives with those operating elsewhere, we find that there is a position in the University's 'Marketing and Development' Unit (located on a campus remote from the DITEE campus) dedicated to marketing university programs to equity students; various units in the DITEE operate a number of recruitment initiatives; and the Division is planning to be more active than previously in the University's science and technology summer school for potential students from Indigenous communities. Also, a number of double degrees have been introduced in the DITEE, which are proving attractive to women students. Preparatory programs exist, and special admissions schemes are in operation. Unfortunately, due to DETYA cutbacks in 1999, there are now only a very limited number of 'equity' scholarships available.

Between them, therefore, the University's central units, and individuals and Schools in DITEE, practise most of the strategies used elsewhere to increase the numbers of equity and diversity students. The organisation of these strategies is, however, largely uncoordinated, and, as we know from Chapter 3, the success of these various initiatives in the Division's separate Schools, is patchy. It is recommended that the Division should reconsider the

establishment of an 'equity' position or unit. The personnel of this unit would be expected to keep themselves informed of the issues of equity and diversity in SET education, and about access strategies that have proved successful elsewhere, in order to initiate, coordinate, and sustain Divisional strategies to recruit equity and diversity students. A Unit of this nature would have other duties too, and these will be introduced in appropriate sections in the next two Chapters.

## Chapter 5: Strategies to improve retention and success

Strategies designed to improve the confidence, satisfaction, retention, and success of equity and diversity students may be classified into two groups (Cronin, Cooper and Roger, 1997):

- initiatives designed to support individual equity and diversity students
- coordinated initiatives to change the structure and culture of SET education.

### ***Initiatives designed to support individual equity and diversity students***

Cronin *et al* (1997) identified the following initiatives as falling into ‘supporting the individual’ category:

- networks of women in SET
- career information and guidance
- role models
- mentoring activities
- bursaries, scholarships and fellowships

And to these we add:

- learning support.

### **Existing University of South Australia SET initiatives supporting individual equity and diversity students**

#### University -wide Initiatives

##### *Learning support*

The Aboriginal and Islander Support Unit (AISU) provides a system of student support for all the University’s Indigenous students known as the *Home Base System*. A particular lecturer is nominated as responsible for a group of students selected either because they are located on the same campus as the lecturer, or because they are studying in the area of the lecturer’s expertise. Home Base lecturers are responsible for administrative and pastoral care issues relating to their students, and for directing students to the right place for help with their academic work.

AISU also provides an *Aboriginal Tutorial Assistance Scheme (ATAS)*. A tutor is assigned to each Indigenous student (or is selected by the student), who helps with study skills, time management, and tackling assignments. Study rooms are available on all campuses, and also off campus in some remote areas for individual or group meetings between students and their tutors.

Learning Connection (a section of the FLC) provide many kinds of support to students. Students may ‘drop-in’ or make an appointment to see a Learning Adviser, or receive assistance by email or telephone. Face-to-face and online workshops and small group sessions are also available on topics such as communications, lifestyle, and computing skills. Learning Connection also offers counselling on careers, and personal issues, and a special program for international students.

### Division ITEE initiatives

#### *Networks*

In 1999 the Division ITEE set up an electronic network for female engineering staff and students, including those at Whyalla. This network disseminates information which is of interest to this community, and it has also been successfully used at least once to appeal for voluntary help; the help requested was with coding the responses to a national survey undertaken by the National (IEAust) Women-in-Engineering Committee.

Prior to establishing this electronic network, the women engineering students had expressed some reluctance to being involved in any women-only activities, for fear of further marginalising themselves from the dominant group (of males). The privacy of email as a means of communication seems to have overcome these difficulties, since no requests have been received by the network manager to delete any names from the list.

Another network available to women students is the Women in Engineering Branch of the South Australian Division of the Institution of Engineers, Australia. This group seeks representation of students from all three SA universities, and at least one student from this Division is usually an active member of its committee.

#### *Learning support*

The School of EIE has encouraged Peer Assisted Learning (PAL) since 1999, particularly in four 1st and 2nd year subjects. In PAL schemes students form their own support groups helping each other with the tasks required for effective studying, such as note taking, questioning, and revision techniques. Each group is led by a more senior student, who is given some training. The School particular targets equity students and international students to participate in these groups, but they are open to all students.

### **Initiatives in other universities**

#### Individual initiatives designed to support equity and diversity students

##### *Career information and guidance*

Like our own Division ITEE, North Carolina College of Engineering has found that there is some resistance amongst female students to having any special provision made for them, for fear of male backlash. The Coordinator for the Women in Engineering Program there has found the same solution – use of email – but for a different purpose. She has set up an email *mentoring program* through which professional engineers working in industry advise female students about careers, and also provides them with role models (Weston 2000).

##### *Role model*

USQ promotes Karen Davis, its first indigenous female engineering graduate, now working for the Queensland Department of Main Roads, as a role model for Indigenous engineering students. Karen overcame many obstacles to join USQ as a mature-aged student, (and once there found she was the only female in a class of 60 students). She stresses the importance of USQ's Indigenous support centre in helping her through her studies (AaeE, 2000).

### **Coordinated initiatives to change SET structure and culture**

Cronin *et al* describe initiatives in this category as those which work:

... at institutional and departmental level, to change the structure and culture of SET ... aim[ing] to build a collaborative and learner-centred environment for women and men in SET (Cronin *et al* 1997, p. 17).

Examples are:

- curricular developments and teaching/learning strategies
- gender equity training
- equal opportunities policies and practices
- coordinated programmes (Cronin *et al* 1997, p. 17).

The same authors identify three keys to the success of such initiatives. They must be

- *comprehensive* (offering a range of schemes or programs to support female and ethnic-minority students, and also to change the SET culture)
- *coordinated* (and include both teaching and support staff)
- all staff (male, female, and from different ethnic groups) must *participate*, - the responsibility must not lie solely with committed (often already-overburdened female) academic staff.

Further, an organisational process strongly recommended by the ETAN (2000) Report<sup>10</sup> is to regularly collect reliable statistical data in order to monitor and review the effectiveness of policies. In addition to “a commitment to developing gender-disaggregated data”, this report adds, it is also necessary to develop “... policies about what statistics to collect, ... [and] equality indicators” (p. 85), and disseminate the statistics collected in ‘user-friendly’ formats. The Report then recommends:

- ensuring a gender balance in scientific decision-making
- ensuring attention is paid to the gender dimension of research
- ensuring adequate expertise (ie ‘gender-equity’ training) (p. 87).

Yet another organisational process recommended is the *professional development* of lecturers. Bianchini *et al* (1999) identify professional development as the key to effecting change in the science curriculum in response to the issues raised by gender and ethnicity. In order to structure this professional development appropriately, these authors researched three questions with academic staff who already had some commitment to an inclusive curriculum. The questions they explored with these staff were:

... (a) their rationales for differential student success in science education; (b) the ways they structure, teach, and assess their courses to promote inclusion; (c) their views on the gendered and/or raced nature of science (Bianchini *et al* 1999).

The findings of this study are detailed and very interesting. It concludes that professional development of the following kinds is needed:

... in professional development activities around issues of inclusions, scientists must be made aware that tensions exist between the goals, norms, and practices of science education and the external forces that constrain students’ aspirations, attitude, and actions. What are the costs and benefits of framing differential student success as influenced by prior academic oversights? ... What can be gained or lost by thinking about the ways women and ethnic minorities are socialized to hold values and skills in opposition to those of science? Discussion of these topics can at least help scientists understand and appreciate the full range and complexity of factors influencing underrepresented students’ decisions and actions in undergraduate science courses.

Two, university scientists must recognize that they and their students do not exist in a vacuum; undergraduate science education programs can only achieve inclusion if supported by the larger social structures in which they are embedded. Scientists should be encouraged to develop outreach programs to their surrounding communities, to inform, engage in dialogue with, and learn from their students’ families and community leaders. Unless and until communities have a better understanding of the roles and responsibilities of science

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<sup>10</sup> The ETAN Report is specifically gender focused, but its recommendations can also be applied to policies and initiatives designed to improve equity for all social and cultural groups.

undergraduate majors, and scientists, a better sense of community needs and practices, may students' lives in academia and in the real world will continue to clash. (Bianchini *et al* 1999).

These authors also offer advice on how to address the questions of the gendered or 'raced' nature of science in professional development activities. They suggest we ask the following questions: "How important is it to encourage scientists to consider feminist views? And once they do, how does one manage the conflicts that inevitably arise when a scientist's conception of or experience with science differs from a feminist's description? Whose conception do we privilege? Whose version of the story is more useful and for what purposes?". Overall, they recommend that "... scientists look more closely at the intersection of views of students, classroom practice, and the nature of science ...". (Bianchini *et al* 1999).

Institutional strategies to change SET culture and structure must therefore encompass policies, procedures and staff development, as well as curriculum and other "classroom" developments. Furthermore, for maximum effect, all of these must form part of a recognisable framework, and be *coordinated*.

### **Existing University of South Australia coordinated initiatives to change SET structure and culture**

#### University -wide Initiatives

##### *Equity policies and practices*

The University has a policy of 'embedding equity':

'Embedding equity' means that a wide range of people has responsibility for equity within a wide range of contexts. It means that the component units of the University have changed their practices and the critical elements of their core business so that these better reflect the commitments of the University's equity agenda (UniSA 1999a, p. 1).

This policy is implemented by requiring all Divisions, Schools and Units to include equity issues in their annual plans, which are used by Senior Management for monitoring performance. The Deans of Teaching and Learning are responsible for coordinating these activities at local level. To inform these plans, the University Planning Unit provides comprehensive, and easily disaggregated, data on access, participation, retention and success of equity students.

#### Division ITEE initiatives

In its attempt to change the SET culture, the Division places particular emphasis on the concept of inclusivity - developing an inclusive culture, creating inclusive educational programs, and developing an inclusive professional culture.

The Division's strategies include

- influencing staff and student culture
- Appointment of female staff
- Curriculum development
- Research and staff development

#### Inclusive culture and inclusive educational programs

One strategy the Division implements to develop an inclusive culture amongst staff and students, is the targeted appointment of female academics. In 1996 the University obtained exemption from the Equal Opportunity Commission to be able to advertise academic positions in engineering for women only. This resulted in the appointment of two female academics in Civil Engineering and one in electronics (Mills, 1996). As a result, the

Engineering Schools now have a credible female staff ratio. These staff are involved in informal mentoring of female students as well as setting up, maintaining and using email lists for communication with female students.

The Division benefited greatly from the university-wide Inclusive Curriculum Project which operated between January 1997 and August 1998. That project was established to advance the University's policy for inclusivity in the curriculum of all courses and subjects. In this Division in particular, it succeeded in advancing the knowledge and practice of inclusivity in the curriculum amongst the staff, and also developed useful resources.

The immediate aims of the Inclusive Curriculum Project were to develop principles, processes and practices for integrating inclusive course development and delivery into mainstream academic procedures. There were subsidiary objectives to support these aims: to produce guidelines, to provide staff development, and to develop and collect resources to assist the development of inclusive curricula. A web-site<sup>11</sup> was developed summarising the project and containing these resources was set up, but regrettably this website has not been updated since the demise of the Project, when its funding ceased in 1998. Another resource developed during the Project is a manual titled "Making Engineering More Inclusive" which was circulated to staff<sup>12</sup>. Considerable interest has been shown by other universities in the manual, and as a result it is now being prepared for publication.

The Project successfully achieved all its aims and objectives. Its objectives and achievements in the Schools of Engineering were acknowledged by the IE Aust through the award of the 1998 National Engineering Excellence Award – Engineering 2000. More detail about the involvement of the Schools of Engineering in this Project is given in Ayre and Mills (1999).

Staff in the Division of ITEE continue to undertake research and development in the area of inclusivity, as well as considering other aspects of equity and diversity. The 2000 Divisional award of an interdisciplinary research grant to fund the Project producing this Report is one such activity. The product of this research will provide the basis for future University equity and diversity SET education and research.

A Divisional Equity Committee (DEC) was set up in October 2000. It provides a single contact point for handling those issues for which responsibility is external to the Division, for example addressing legal obligations in terms of Affirmative Action. DEC reports on any division-wide equity matters to Divisional Executive. It also provides a mechanism to assist the implementation and monitoring of equity initiatives in the Division's Schools, and to communicate information about these across the Division.

#### Improving success and success rates

Many of the Division's (male and female) academic staff are providing additional informal mentoring to equity and diversity students. The role models offered by female and ethnic minority academic staff are also invaluable in motivating students from these social and cultural groups to succeed.

#### Career information and guidance

The University's 'Learning Connection' provides a graduate employment program, together with individual counselling and a range of careers education seminars. Its resources include a careers reference library on each campus.

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<sup>11</sup> at <http://www.unisanet.unisa.edu.au/flc/inc-curr>

<sup>12</sup> copies available from Julie Mills

### **Initiatives in other universities**

The main strategies employed elsewhere which differ from what is already being done at the University of South Australia, are listed below.

#### Coordinating SET equity initiatives

In Chapter 4, the value of a dedicated 'equity' or 'women-in-engineering' unit, (or at least an individual), was mentioned in the context of recruiting equity students to SET programs. It is usual, though, for such a unit to have wider responsibilities than simply recruitment, many of which could be described as aiming to change SET culture and structure. For example, at the University of Washington, the Women in Engineering (WIE) initiative includes:

... peer, professional and faculty mentoring; tutoring; WIE study centres and study classes; scholarships and fellowships; support groups; seminars; annual WIE conference; outreach to schools; and publications including a quarterly newsletter; resource directory and conference proceedings (Cronin, Cooper *et al* 1997, p. 24).

#### Equity training

Providing staff with training in the equity and diversity issues of SET education, and developing resources to support this training, is a strategy also mentioned by a number of other universities, such as Heriot-Watt; University of California, Davis; NECUSE (a consortium of New England universities), and Purdue University (Cronin, Cooper *et al* 1997). The resources developed are usually in the form of 'guidelines', videos, and websites.

#### Use of surveys

Cronin, Cooper *et al* (1997) also point out that a number of universities (such as Heriot-Watt, and St. Andrews), have used the device of surveys to identify issues of concern to equity and diversity students, and then used these findings to construct appropriate strategies to encourage the development of an inclusive teaching and learning culture.

### **Chapter summary and conclusions**

This chapter has considered strategies designed to improve the confidence, satisfaction, retention and success of equity and diversity students. Some of these strategies focus on supporting the individual student, such as encouraging students to join, or form, networks; providing role models; providing learning support; and financial support in the form of targeted scholarships and fellowships. Other strategies aim to make the culture of SET academic departments more inclusive of equity and diversity students. These strategies may include proactively interpreting and applying equal opportunities policies and practices; encouraging the development and use of more inclusive curricula; providing appropriate professional development; and co-ordinating all these strategies.

As with the access strategies discussed in Chapter 4, the University of South Australia is implementing most of the strategies designed to improve retention and success identified in the research, but again like the access strategies, (and referring to the data analysis in Chapter 3), the success of these strategies in the SET disciplines is mixed. There is emphasis in the literature on the importance of SET-focused *coordination* of all these strategies, and this, therefore, must be our recommendation for improving retention and success of the equity and diversity groups in the SET disciplines.

## Chapter 6: Diversity Strategies

Earlier in this Report we have identified three advantages for universities, employers, and society in general, arising from student diversity: improved educational quality, preparation for professional practice, and a more informed and responsible mainstream society. Any strategies which improve the intellectual and practical connection between students and diverse social and professional communities will promote these aims. As with the strategies discussed in the previous two chapters, however, their effects are greatly enhanced if they form part of an organisational policy framework, rather than being simply the outcome of the enthusiasms and commitments of individual lecturers.

Firstly, therefore, the reader is referred to the section headed 'Coordinated initiatives to change SET structure and culture' in the previous chapter, for advice as to how to establish and implement policies and procedures which facilitate the necessary institutional cultural change. Below we provide examples of both 'organisational' strategies, and 'classroom' strategies which will promote the development of intercultural competence.

### ***Organisational strategies***

Bradley (1997) listed a number of strategies for promoting internationalisation of the curriculum. Reorganising, and adapting these slightly (including replacing the word 'internationalisation' with 'intercultural competence') these strategies become:

- An explicit policy for promoting an intercultural curriculum
- Structural support for this process
- Intercultural competence embedded in any formal statement of graduate outcomes
- Intercultural competence to be a goal of all academic and support units – and achievements of specific objectives to be monitored
- Intercultural competence embedded in formal requirements for course development, review and quality assurance processes
- Quality assurance processes and a research-oriented approach to initiatives in the area of intercultural competence to ensure that programs, services and processes are of the highest standard
- Providing academic staff with opportunities to become and remain interculturally contemporary and up-to-date in their fields.

### ***Classroom strategies***

Students should be encouraged to seek out approaches to SET issues which arise in other countries and other cultures. Snow conditions, for example, and different water table levels, will affect the construction of roads in different parts of the world. In countries with unreliable power supplies, are there feasible alternatives to industrial and domestic power appliances regarded as essential in more 'advanced' economies? Variations of environmental priorities across terrains will affect all kinds of industrial enterprises, as will different attitudes to issues such as nuclear power, and unsafe substances.

The impact of these different perspectives will be greatly enhanced if students have opportunities for live dialogue with members of different cultural groups, in addition to searching the literature. Discussion with equity and diversity student classmates is one way to achieve this, although care needs to be exercised here since students from these groups may not wish, or have sufficient knowledge, to represent their communities as 'experts' in these fields (Hellmundt, Rifkin and Fox 1997). Other strategies for achieving this exposure are to

bring in experts from other communities as lecturers, or to provide opportunities for students to live and work in communities with which they are unfamiliar (Luong, Crockett, Lundberg and Scarino 1996).

Most universities operate exchange schemes for this purpose, but the take up is limited to those who are not prevented from spending a period overseas by family circumstances and finances. An alternative is to set up a 'virtual' international, or intercultural, group of students to work together, but remotely, using electronic communications technologies, on a SET project which provides opportunities to compare and contrast cultural priorities, resources, and practices. An example might be to develop systems and practices for conserving the radio spectrum by reducing electromagnetic pollution. In addition to its technical challenge, such a project would require discussion of various regulatory practices, since different interference-reduction regulations operate in different countries.

### **Existing SET Diversity initiatives in the University of South Australia**

#### Organisational strategies

##### *Policies and statements*

The University of South Australia has identified seven 'qualities' it aims to develop in its graduates. Several of these 'Graduate Qualities' either specifically or in the subtext, promote international and intercultural competence. Quality 7 requires students to demonstrate 'international perspectives', as well as "appreciate the importance to professional practice of social issues arising from multicultural Australia". Quality 1 ('body of knowledge') expects students to 'recognise the social and historical context of knowledge'. Quality 4 ('work autonomously and collaboratively') encourages students to "work collaboratively with different groups ...". Quality 5 ('committed to ethical action and social responsibility') expects students to "demonstrate responsibility to the community ...". (UniSA, 2000).

The Graduate Qualities form the framework for all formal curriculum development in the University. All program and course approval applications are required to state how they will develop each graduate quality, thus providing a powerful tool for ensuring the implementation of the policy.

#### Classroom strategies

##### *Working in other communities*

Joan Gibbs of ERM, and also a member of THERG, the group responsible for producing this Report, provides an example of a diversity initiative which involves working in other communities. An environmental science course on which she teaches includes Indigenous perspectives on landcare. Students are introduced to these perspectives on fieldwork visits to Indigenous communities, by Indigenous people still caring for their traditional lands, rather than in a university classroom (Gibbs, 1998). Not only does this experience widen all students' understanding of landcare, it helps to improve racial understanding. Graduates of this course are eagerly sought by mining companies, partly because their approaches to landcare involving a combination of traditional and western conservation methods have been shown to be effective, and partly because these graduates have acquired the skills to liaise productively with local Indigenous communities, and to be advised by them.

##### *Virtual intercultural groups*

In 1999 the Heads of the University's (then) two Schools of Engineering were awarded an Internal Individual Teaching and Learning Grant for an innovative project to promote cross-cultural student cooperation. The project established a means for students to interact with their counterparts in other countries by the use of electronic communications technologies. Using email and the world wide web, UniSA engineering students collaborated remotely but effectively on projects with students in Poland and France.

### **Initiatives in other universities**

The Faculty of Built Environment and Technology at *Queensland University of Technology* (QUT) has set up a project to develop curricula which "... prepare graduates with the awareness and skills for working effectively in diverse communities, locally and globally, based on the principles of sustainable development" (Messer and Kelly, 1999). The first stage of this project was to develop a first year subject taken by all engineering students: 'Technology and Society', one of the aims of which is to develop the skills and understandings necessary to negotiate cultural issues and problems. The context for this exercise is a project to develop a disused railway yard into a Theme Park.

### **Chapter summary and conclusions**

One outcome of the 'equity' debates was the recognition that by acknowledging the different values, perspectives, and learning approaches of students from social and cultural groups who had not traditionally opted for SET education, the perspectives of all the students in a class were widened, thus improving the quality of the education. Recognition of the positive contributions made to the educational environment, not only by the presence of diverse groups of students, but also by adapting the curriculum to address a range of student experiences and cultural issues, is now established, and the value of professional and personal 'intercultural competence' is increasingly appreciated. Intercultural competence involves being able to practise professionally in countries and communities with differing physical resources and conditions, values and standards' political and legal frameworks, customs and cultures.

Implementing both the University of South Australia's 'equity' and 'internationalisation' policies in classrooms and laboratories, as well as the guidelines for several of the University's Graduate Qualities, should lead to students becoming interculturally competent. The challenge here is to ensure that the actual practice goes beyond the rhetoric, and that the learning environment genuinely encourages consideration of perspectives and approaches arising from alternative cultural viewpoints. Although some of these skills and knowledge can be acquired from books and other written sources, alternative learning experiences are needed for students who learn more effectively by 'doing' than by reading, by for example, arranging for direct communication with members of other communities (by visits or exchanges), or in intercultural 'virtual' classrooms.

## Chapter 7: Implications for the Division

The Division ITEE and its Faculty predecessors have made considerable efforts and initiated a range of strategies to address equity and diversity issues. Over the past decade or so, these have included outreach programs targeting Years 10 – 12 high-school students; ‘vocational’, or ‘summer’ schools; scholarships; consultation with the Unaipon School and AISU about developing strategies to improve Indigenous student numbers and performance; and developing and implementing inclusive curriculum guidelines.

Although there have been some noticeable improvements in the equity performance indicators, the near-absence of Indigenous students in the Division, and the low participation of women in the Schools of Engineering continues to cause concern. Retention and success of female students however is at least equal to, and often exceeds, that of the male students in these Schools. In CIS and GPB, on the other hand, not only is there low female participation, but also low retention and success rates for this, and other equity groups.

Up till now, equity and diversity strategies initiated by Schools in the Division have relied largely on the drive, enthusiasm, and commitment of individual numbers of staff, and such initiatives are thus endangered if those staff leave or are asked to undertake other duties deemed by the School management to have higher priority.

A way has to be found to consolidate and sustain these initiatives. Despite the existence of a Divisional position of ‘Access and Equity Officer’, whose job description includes providing “... advice to Divisional staff on University academic administration and equity policies and procedures ...” and assisting “... in the review, development and implementation academic administration and equity activities ...”, the workload of the incumbent does not currently permit attention to these equity duties. A proposal in 2000 to appoint a 0.8 Divisional Equity Officer who could support, sustain, and develop individual Schools’ equity initiatives, and integrate them across the Division as a whole was rejected on the grounds of cost. The hope was expressed that the new Divisional Equity Committee would perform many of the functions of the proposed Equity Adviser, but we remark that while a committee can monitor, evaluate, and revise strategies, it cannot *implement* them.

Although we have emphasised the advantages of a Unit, or at least an individual, responsible for research and coordination of Divisional activities, and for initiating and implementing some of them, inclusive *curricular* and *pedagogic* initiatives must be the responsibility of the individual science teachers or lecturers in the classroom, thus extending the lecturer’s role to that of ‘cultural warrior’ (Rodriguez, 1999). Rodriguez notes that wide-ranging research evidence has been obtained on cultural issues which relate particularly to science education, but he questions how this research has affected classroom practice or teachers’ pedagogies. He believes that it is important to deal head-on with resistance to change in pedagogy, especially that displayed by new teachers who have been ‘apprenticed’ to old methods by their own school experience and observation. He sees a need to use multiple theoretical frameworks in developing pedagogies, to acknowledge resistance to change among teachers, and to develop strategies which will allow research results to become a catalyst to counter this resistance.

### **Future Research and Practice**

Adopting Rodriguez’s perspective, it seems clear that staff within the Division who are already “cultural warriors” (or, in our context, perhaps “equity” warriors) need to be encouraged and empowered to use innovative pedagogical methods or strategies to infuse matters of diversity into curricular content (e.g. course work that requires students to focus on members of diversity groups and the problems they experience in today’s society). This approach also offers promising opportunities for action research and evaluation, to determine the effect of particular pedagogies on student retention. Other possibilities include researching

the consequences of revision of curriculum content and teaching process designed to enhance students' exposure to multiculturalism, or diverse perspectives and values; for example in the context of 'virtual' intercultural project work using electronic communications technologies.

Future research might usefully include an examination of the practices of "equity" warriors who have developed sustainable equity initiatives over a long period, to identify the features which allow the initiatives to be embedded in the culture of an institution rather than die out with the individual staff member.

Conference and workshop attendance is often a useful catalyst to promote diversity across the curriculum, but a regular staff forum within the Division allowing "equity warriors" an opportunity for encouragement and peer review would also be a useful mechanism for sustaining equity initiatives.

While academic staff members have a major role to play in the "battle" for the participation and retention of equity group students, this work needs also to be embedded in all the processes with which the Division is engaged; to include, for example, marketing staff who are often in the frontline of this endeavour. Indeed, an evaluation of our own current marketing techniques, focusing on a comparison between our practices and those of the apparently more successful universities would be another useful research direction.

This Report has been prepared to provide the first step in a renewed Divisional approach to improving its equity and diversity profile. It presents the theoretical background, the issues, and the data, needed to construct an informed and focused strategy. It also suggests new research areas. The authors, together with the other members of the Technology in Higher Education Research Group, look forward to discussing this Report with other University stakeholders in this field, and contributing their commitment and capabilities to the development of any resulting new initiatives.

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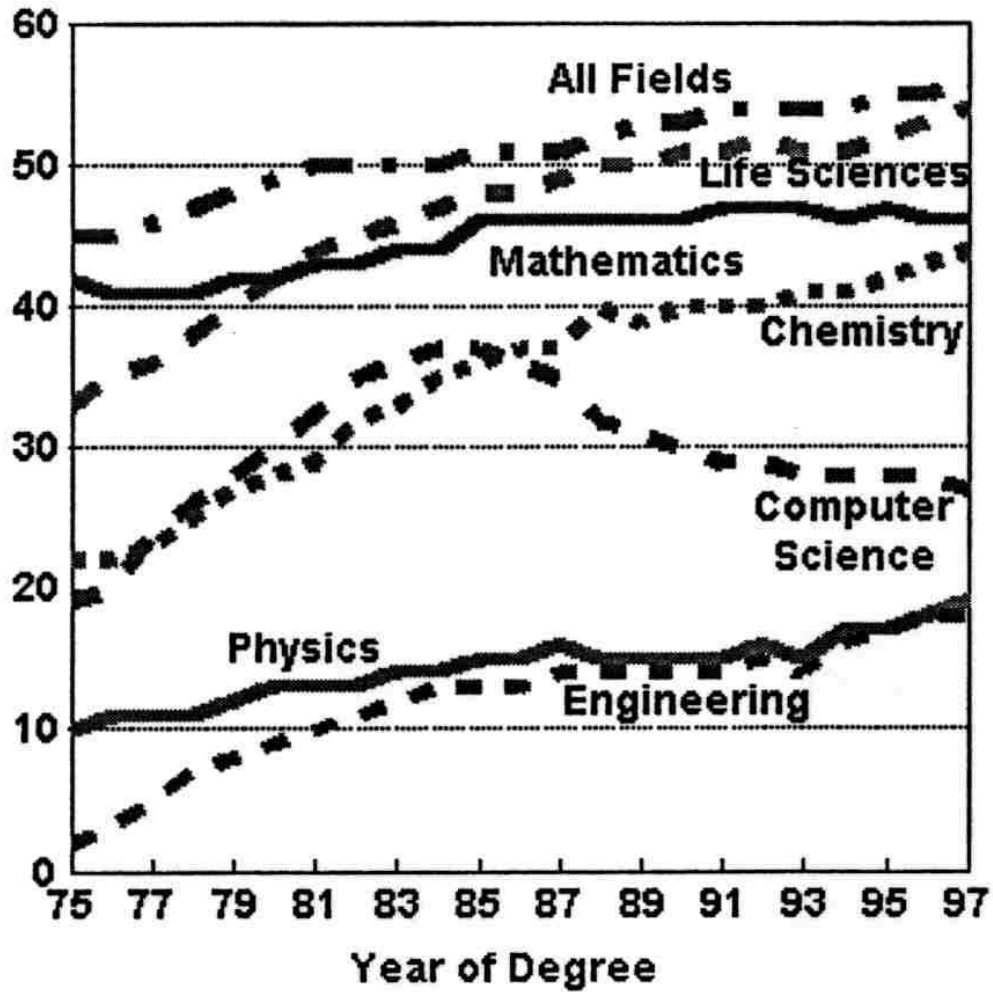
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## Appendix A: Abbreviations Used

AACU	Association of American Colleges and Universities
AaeE	Australasian Association of Engineering Education
AISU	Aboriginal and Islander Support Unit, University of South Australia
AME	School of Advanced Manufacturing and Mechanical Engineering, University of South Australia
ASSETS	Aboriginal Summer School in Technology and Science, University of South Australia
ATSIC	Aboriginal and Torres Strait Islander Commission
CIS	School of Computing and Information Science, University of South Australia
DEC	Divisional Equity Committee, Division ITEE, University of South Australia
DETYA	(Australian Federal Government) Department of Education, Training, and Youth Affairs
DITEE	Division of Information Technology, Engineering and the Environment, University of South Australia
EGG	School of Engineering, University of South Australia (abolished in 2000)
EIE	School of Electronic and Information Engineering, University of South Australia
ERM	School of Environmental and Recreational Management, University of South Australia
ETAN	European Technology Assessment Network on Women and Science
FEFC	(UK) Further Education Funding Council
FLC	Flexible Learning Centre, University of South Australia
IEAust	Institution of Engineers, Australia
IEEE	(US) Institute of Electrical and Electronic Engineering
ITEE	Division of Information Technology, Engineering and the Environment, University of South Australia
ITR	Institute for Telecommunications Research, University of South Australia
GMC	School of Geoscience, Minerals, and Civil Engineering, University of South Australia
GPB	School of Geoinformatics, Planning and Building, University of South Australia
HERDSA	Higher Education Research and Development Society of Australia
MAT	School of Mathematics, University of South Australia
NCGCD	National Centre for Gender and Cultural Diversity
NESB	Non English Speaking Background
NSERC	Natural Sciences and Engineering Research Council of Canada
PAL	Peer Assisted Learning
PES	School of Physics and Electronic Systems Engineering, University of South Australia (abolished 2000)
SA	South Australia
SACE	South Australian Certificate of Education
SES	Socio-economic status
SET	Science, engineering, and technology
TAFE	Technical and Further Education
TER	Tertiary Entrance ????
THERG	Technology in Higher Education Research Group, University of South Australia
UniSA	University of South Australia
USQ	University of Southern Queensland
UTS	University of Technology, Sydney
WISET	Women in science, engineering and technology

**Appendix B: Proportions of Bachelor's Degrees in various sciences gained by women in the US, 1975 - 1997**



Source: Statistical Research Center, American Institute of Physics, 2001

## Appendix C: Other ‘staged’ or ‘phased’ developments of an inclusive curriculum

### 1. Rosser’s Phases of Transformation of the Science Curriculum

The phases of curriculum transformation may be visualized as a continuous spiral with overlapping components rather than as discrete stages; many of the pedagogical techniques are appropriate to accompany multiple stages of the curriculum. (Rosser 1996, p.4).

Stage	Title	Characteristics	Strategies to achieve change
1	Absence of women is not noted	Assumption that the objectivity of science renders it immune to gender considerations	Acknowledge gender influences, and seek ways to incorporate them appropriately in the curriculum
2	Recognition that most scientists are male and that science may reflect a masculine perspective	Science views the world from a male perspective	- explore issues of social concern - set open-ended investigative-type problems
3	Identification of barriers that prevent women from entering science	Exploring why women are not attracted to studying science; how to attract them and how to reduce barriers at entry	Consider the learning environment as well as entry issues; remove the “chilly climate” experienced by many women students
4	Search for women scientists and their unique contributions	Include the contributions of women scientists, and discuss why they have often been ‘lost’.	- teach in cooperative and interdisciplinary ways - discuss the social benefits of technological progress
5	Science done by feminists and women	Accepting and incorporating women’s different perspectives and ‘ways of knowing’ in the study of science.	- encourage development of theories and hypotheses that are relational, interdependent, and multicausal - use qualitative and quantitative methods in data gathering
6	Science redefined and reconstructed to include us all	Incorporating all of the above into a transformed inclusive mainstream curriculum	The philosophy, aims, objectives and content of the curriculum must be based on the principles of inclusivity, as well as the way the curriculum is delivered

[adapted from Rosser, 1995, pp. 4-17]

### 2. Barnett’s three meanings of ‘inclusive’:

	Meaning	Characteristics
1.	Not being exclusive	Not excluding minority or oppressed groups from one’s thinking, planning and providing.
2.	Being actively inclusive	Taking account of views and beliefs other than the dominant ones, validating them, publicising them, and responding to the needs and aspirations created by them.
3.	Being actively opposed to exclusivity	Opposing discriminatory practices and engaging in affirmative action for minority and oppressed groups.

[adapted from Barnett, 1994, p. 18]