1. INTRODUCTION

This study grew out of a review of the first programming course at the University of Sydney. From analysis of women’s participation rates and success in Computer Science at the University of Sydney, we had cause to suspect that there were particular problems facing women at the early stages of their studies. (Kay and Prosser, 1983) We knew that at the University of Sydney, fewer women enrolled than men, women were more likely to drop out in the early stages and they were under represented at the top of the class. We wanted to investigate whether these trends applied more widely and to seek possible explanations for them. Accordingly, there were three major objectives in the study.

1. To gain a quantitative picture of the representation of women in Australian computing courses that are professionally accredited. In particular, this study aimed to establish the number of women starting such courses, the number finishing and the number being awarded highest grades in the courses.

2. To identify issues that students and staff perceive as relevant for the representation and success of women in such courses.

3. To evaluate some approaches to providing support and assistance to women at the beginning of their computing studies.

This study focuses on courses offered in Australian CAEs and universities which have a major role as vocational training for programmers, analysts and other professionals with a high degree of computing skill.

That women appear to be disadvantaged is of concern, in terms of educational equity and access to jobs that require formal computing qualifications. This, in turn, must have consequences for the computing industry as it is unable to take advantage of the widest pool of expertise. These concerns have been described by Harding (1982). She observes the effects of women’s lower representation in terms of

... needs at the national level, when industrial innovation is lagging behind because of a shortage of technically qualified personnel; the requirements of educational equity, when so many openings in many fields of employment require scientific qualifications, and the development of the full potential of the individual, which is not possible unless girls, as well as boys, are given the opportunity to experience the scientific way of thinking and reasoning.

Harding, 1982:570

There has been little Australian work reported on women’s participation in tertiary computing courses. Indeed, there has been very little at that level elsewhere. In this study we sought to collect data on women’s participation in professionally accredited computing courses, with particular emphasis on the transition period, when students first enter computing courses. We were fortunate in having the support of many individuals in computing departments across Australia who were prepared to collect information on participation rates.
The collection of such statistics is relatively straightforward, though time consuming. It is much more difficult and important to gain some insight into the reasons underlying women’s relatively low levels of participation. To shed light on the issues that might influence women’s participation in computing courses, we took several approaches. As well as gathering basic distributive data, we interviewed both staff and students at a small number of representative institutions. We also undertook an analysis of the handbook information that is available to students at entry to the courses.

*Characterisation of the computing courses*

Before we consider the approaches and findings of this study, it is useful to characterise the nature of the courses covered. We emphasise that this study is limited to courses with accreditation at level I from the Australian Computer Society. These are courses of three or four years duration and they lead to a degree. Their graduates can typically find employment as programmers and systems analysts. They have been described as follows:

> These people are mainly concerned with applying the computer to specific problems of commerce, engineering and other disciplines. ... (they) determine ways in which problems can best be solved using the computer and (they) implement the chosen method as a computer program.
> Pirie, 1982:4

Also, a small but significant proportion of students will become computer scientists:

> The computer scientist is concerned with the scientific study of computers, their operation and the theory behind them. This includes research into computer design, operating systems, programming languages, information systems and the theory of automatic machines. Such a person will normally be a university graduate with a higher degree in Computer Science, and may be employed in a university or research institute in work in a large computer installation or for a firm that manufactures computers.
> Pirie, 1982:4

In addition, a number of the courses produce multi-disciplinary graduates who have computing skills sufficient for the above jobs but whose course of study also has other emphases, most commonly on business or commerce, but often some quite different area, such as education, music or engineering.

The courses that we have studied place varying emphasis on the following aspects of computing: Computer Science; Data Processing; and Information Systems. Courses whose primary emphasis is on Computer Science typically concentrate on technical and mathematical aspects of the discipline. Those courses with a heavy Data Processing or Information Systems emphasis deal with the application of computers, especially in the business area and they typically stress communication and broad problem solving skills.

Courses with a Computer Science emphasis tend to be located in Universities while Colleges of Advanced Education typically stress business applications. Institutes of
Technology tend to offer courses that emphasise both aspects. Where a course is offered within a University, it is usual for students to study in another major and while this is commonly in a closely related area like Economics or Mathematics, it can include a considerable range of other disciplines including Music, Physics or Psychology. By contrast, courses in the CAE sector are largely self-contained and computing constitutes the major focus of the degree program.

1.1 Methodology

This overview of the methodology is brief. (See Appendix IV for more detail.) As our first task was to collect statistical data on women’s participation rates in accredited computing courses, we surveyed all departments offering such courses. (See Appendix III for a list of the courses.) In addition to the statistical data on women’s representation at the early stages of the courses, the questionnaire collected other quantitative and qualitative data to provide a context for the statistical analyses. (See Appendix V for the questionnaire.)

A smaller number of institutions was selected for student and staff interviews. These institutions represented a wide range of those covered in the questionnaire in that they included courses with low, medium and high representation of women. At these institutions, we interviewed a sample of students in their final year. We also interviewed at least one member of staff with administrative responsibility for the first year of the course and one with extensive contact with first year students. (In some cases, one person met both criteria.)

The other component of the study involved analysis of handbooks and other materials that are made available to students entering the courses. These materials were sought when we established contact with departments that were asked to answer the questionnaire.

In this report, we discuss only those issues that arose from two or more sources of information. In this sense, our interpretations can be considered as conservative.

The investigation of intervention strategies was done in parallel with the other aspects of the study. It was motivated by the initial work at the University of Sydney and was investigated there.

Form of this report

Rather than report the findings of the individual components of the study, we have integrated them to match the initial objectives of the study. Our report has three main components:

- a description of quantitative findings;
- a discussion of qualitative findings and emergent issues and
- a description of the intervention strategies we investigated.

Accordingly, Section 2 describes the distributive data collected in the questionnaire that was sent to all computing courses with professional accreditation from the Australian
Computer Society at level 1.

The third section discusses the issues that help illuminate the statistical findings. These issues emerged as significant throughout the study.

In Section 4, we review the approaches to intervention that were investigated.

The concluding section summarises the central statistical findings and issues.
2. DISTRIBUTIVE DATA

We emphasise that, in spite of a generally good response rate, the statistical data must be regarded as descriptive for two major reasons: the first is that we have only collected data for two years (and in some questions, only for one year); the second reason relates to the small population size. When we examined correlations between a pair of low response questions, the number of courses covered by any one combination of responses was often small, either because of the small size of the full sample or because of the particular response rate. (See Appendix IV for details of the response rate.)

Table 1 shows both women’s and men’s representation among students enrolling in the courses and the proportions persisting with their studies beyond the first few months. It also indicates women’s achievement in terms of pass rates in the first units of the courses and the proportion of women at the top of the class for the first units and for the course as a whole. The last column indicates the difference in the proportions for women and men: for example, the proportion of women dropping out was 46% higher than for men. For this and the other tables in this section, the sample size gives the number of courses or first year units on which the analysis is based.

**TABLE 1. Summary of statistical findings**

<table>
<thead>
<tr>
<th>Average proportion of students</th>
<th>women % (Sample size)</th>
<th>men % (Sample size)</th>
<th>women to men %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information for students at the beginning of their course</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entering</td>
<td>84 28.2 (37)</td>
<td>85 27.7 (43)</td>
<td></td>
</tr>
<tr>
<td>dropping out</td>
<td>84 15.0 (33)</td>
<td>85 15.4 (39)</td>
<td>+46</td>
</tr>
<tr>
<td>passing first units</td>
<td>84 73.0 (37)</td>
<td>85 71.3 (33)</td>
<td>-3</td>
</tr>
<tr>
<td>achieving top grades</td>
<td>84 10.8 (38)</td>
<td>85 12.7 (35)</td>
<td>-4</td>
</tr>
<tr>
<td>Information for students in the final year of their course</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>graduates</td>
<td>85 26.1 (34)</td>
<td>85 10.8 (25)</td>
<td>+22</td>
</tr>
<tr>
<td>achieving top grades</td>
<td>85 13.2 (25)</td>
<td>85 10.8 (25)</td>
<td></td>
</tr>
</tbody>
</table>

In the remainder of this section we discuss the averages reported in this table and the range and distribution of each set of data. We also describe differences we observed between institutions that had higher proportions of women. We report only those differences with a medium to large effect size.\(^1\)

---

\(^1\) The criterion for selecting significant cross-tabulations was the magnitude of the differences rather than their statistical significance, this being consistent with a descriptive analysis. (Cohen, 1977)
Women’s representation at entry

As Table 1 above indicates, women constitute somewhat over a quarter of those who enrol in computing courses. There was no course in which equal numbers of women and men started and in only one did women constitute more than 40% of initial enrolments. At the other extreme, there were few courses where women represented less than one fifth of enrolling students (and they appear to have little or no drop in enrolments by the 30 April, which suggests that earlier enrolment figures were not available.) These findings held over both years studied and are consistent with data on graduation rates collected over several years by Daniel. (Daniel, pers. comm.)

On the basis of the average proportion of women enrolling, we identified those courses with higher and those with lower proportions of women enrolling. We then looked at other information available from the questionnaire to see if these two groups of courses differed from each other. Courses with a heavy emphasis on Information Systems or Data Processing tended to have more women entering, as the tables below indicate. For example, in 1984 78% of the courses with heavy emphasis on Information Systems had higher proportions of women enrolling. (N9 indicates that there were actually 9 such courses, so we can calculate that 7 of these had more women enrolling than the average for all the courses we surveyed.)

### TABLE 2. Initial enrolment and Information Systems emphasis

<table>
<thead>
<tr>
<th>Initial enrolment of women</th>
<th>Heavy emphasis</th>
<th>Some emphasis</th>
<th>Little or no emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 % (N9)</td>
<td>1985 % (N13)</td>
<td>1984 % (N18) 1985 % (N19)</td>
</tr>
<tr>
<td>lower proportions</td>
<td>22</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>higher proportions</td>
<td>78</td>
<td>44</td>
<td>50</td>
</tr>
</tbody>
</table>

### TABLE 3. Initial enrolment and Data Processing emphasis

<table>
<thead>
<tr>
<th>Initial enrolment of women</th>
<th>Heavy emphasis</th>
<th>Some emphasis</th>
<th>Little or no emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 % (N7) 1985 % (N9)</td>
<td>1984 % (N17) 1985 % (N19)</td>
<td>1984 % (N13) 1985 % (N15)</td>
</tr>
<tr>
<td>lower proportions</td>
<td>29</td>
<td>53</td>
<td>46</td>
</tr>
<tr>
<td>higher proportions</td>
<td>71</td>
<td>47</td>
<td>54</td>
</tr>
</tbody>
</table>

In much the same way, the tables below show that women’s representation related to the mathematical emphasis of the course. Lower proportions of women enrolled in courses that placed more importance on HSC maths for problem solving and mathematical proof skills. Since courses with an Information Systems or Data Processing focus tend to be less mathematical, this combination of findings is consistent. (By contrast, Computer
Science courses have a stronger emphasis on these mathematical skills.)

**TABLE 4.** Initial enrolment and importance of HSC maths for students’ ability to cope with problem solving skills required in the course

<table>
<thead>
<tr>
<th>Initial enrolment of women</th>
<th>Very important %</th>
<th>Important %</th>
<th>Little importance or irrelevant %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 (N13)</td>
<td>1985 (N15)</td>
<td>1984 (N5)</td>
</tr>
<tr>
<td>lower proportions</td>
<td>77</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>higher proportions</td>
<td>23</td>
<td>40</td>
<td>80</td>
</tr>
</tbody>
</table>

**TABLE 5.** Initial enrolment and the importance of HSC maths for students’ ability to cope with mathematical proof in the course

<table>
<thead>
<tr>
<th>Initial enrolment of women</th>
<th>Very important or important %</th>
<th>Little importance or irrelevant %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 (N12)</td>
<td>1985 (N13)</td>
</tr>
<tr>
<td>less women enrolling</td>
<td>66</td>
<td>30</td>
</tr>
<tr>
<td>more women enrolling</td>
<td>33</td>
<td>70</td>
</tr>
</tbody>
</table>

One extreme counterexample to this trend was in a course with a very restricted quota on entry: this course had by far the highest proportion of women enrolling in our sample. Yet it had a strong Computer Science emphasis and a lesser emphasis on Information Systems and less still on Data Processing. The respondent for that course also commented that:

The majority of female students are not Australian residents whereas a slight majority of males are Australian.

The particular combination of circumstances that apply in this course appears to have attracted unusually high proportions of women.

**Early dropout**

We determined the early dropout rate by comparing the number of students enrolled at April 30 against the number who initially enrolled in each of the first units. As indicated in Table 1, this ratio gives an early dropout rate for women of 15% against a rate of only 10% for men. There was a large range of early dropout rates reported across the courses: about a quarter of the courses actually had lower discontinuation rates for women than for men and most courses had early discontinuation rates for women below 25% and below 20% for men. As a small proportion of enrolment figures come from institutions which were unable to provide enrolments earlier than April 30, our findings may be interpreted as conservative.
Questionnaire responses for courses with higher dropout rates indicate that aspects of the mathematics bridging facilities offered, the emphasis on English and some of the teaching methods were related to dropout rates. We consider each of these in turn.

Although the actual degree of emphasis on mathematics in the first year of the course did not relate to differential dropout rates, the location and availability of mathematics bridging courses did relate. This is illustrated in the table below.

**TABLE 6.** Early dropout rate and availability of mathematics bridging courses

<table>
<thead>
<tr>
<th>Courses with</th>
<th>Mathematics bridging course availability</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>within department %</td>
<td>elsewhere in institution %</td>
<td>not available %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower dropout rate for women</td>
<td>88 66</td>
<td>31 41</td>
<td>100 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher dropout rate for women</td>
<td>13 33</td>
<td>69 59</td>
<td>0 20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower dropout rate for men</td>
<td>62 44</td>
<td>37 59</td>
<td>78 50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher dropout rate for men</td>
<td>38 56</td>
<td>63 41</td>
<td>22 50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In both 1984 and 1985 data, we observed that where there were internal bridging courses, the early dropout rate was lower for women. The same trend applied to a lesser degree for men in one year (1985). That a shortfall in mathematics background might be better addressed within the department could be explained in the following ways:

- internal bridging courses may be better integrated with the needs of the course;
- those departments with internal bridging courses might, by virtue of running them, be more aware of students’ needs.

The table above also indicates that retention rates were higher where no maths bridging course was available at all. In interpreting this, we repeat that the actual degree of mathematical emphasis and the course orientation did not relate to the discontinuation rate. We can offer the following explanations:

- in some cases, bridging courses were irrelevant because the computing course had little maths emphasis;
- for others, the first units may, themselves, cover all requisite mathematics and no separate bridging course is necessary.

A further study might well investigate these possibilities by focusing more tightly on the role of mathematics background for student’s survival in the very early parts of the course. At this stage, it is also important to note that we have no direct evidence of the mathematical background of the students who discontinued from these courses, except in the case of the University of Sydney, where students who drop out early in the first units are more likely to have lesser mathematical backgrounds.
The next set of factors relate dropout rates and the emphasis on English in the first year of the course. Where there was a greater emphasis on the development of English writing skills in the first year of the course and where remedial English was offered, we observed higher retention rates for women and, in one year (1984) for men as the following tables show.

**TABLE 7.** Early dropout and emphasis on development of English writing skills in the first year of the course

<table>
<thead>
<tr>
<th>Courses with</th>
<th>Heavy or some emphasis</th>
<th>Little or no emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower dropout rate for women</td>
<td>89 83</td>
<td>52 48</td>
</tr>
<tr>
<td>higher dropout rate for women</td>
<td>11 17</td>
<td>48 52</td>
</tr>
<tr>
<td>lower dropout rate for men</td>
<td>78 50</td>
<td>48 56</td>
</tr>
<tr>
<td>higher dropout rate for men</td>
<td>22 50</td>
<td>52 44</td>
</tr>
</tbody>
</table>

**TABLE 8.** Early dropout and remedial English assistance

<table>
<thead>
<tr>
<th>Courses with</th>
<th>Availability of remedial English assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Available Not available</td>
</tr>
<tr>
<td>lower dropout rate for women</td>
<td>75 64 55 62</td>
</tr>
<tr>
<td>higher dropout rate for women</td>
<td>25 36 45 38</td>
</tr>
<tr>
<td>lower dropout rate for men</td>
<td>60 36 54 92</td>
</tr>
<tr>
<td>higher dropout rate for men</td>
<td>40 64 45 8</td>
</tr>
</tbody>
</table>

That women fare better at the very early stages of courses with greater emphasis on English might be explained in several ways, including the following:

- these courses may provide a closer match between the expectations of women and the first stages of the course;
- these courses may be less alienating for women.

Williams and Pepe (1983) found that students who discontinue their studies are strongly influenced by the quality of their experiences in the first couple of months of their studies. We will return to these issues in Section 3, where we consider related evidence from other aspects of the study.

*Pass rates on first units of the courses*

The pass rates for first units are more than a simple indication of achievement in the early part of the course. Because they indicate success at a stage between the tenth and fifteenth week of the course, they also include elements of early dropout.
Table 1 indicates that, on average, pass rates in the first units were a few percent lower for women than for men in both 1984 and 1985. The bulk of first units had pass rates of at least 55% for women and at least 60% for men. It should be noted that many of the courses reported vastly differing pass rates over the two years for which data was collected and about a third had large differences between pass rates for women and men.

We observed that courses with a heavy emphasis on English writing skills in the first year had not only a lower dropout rate for women, but also higher pass rates as shown in the table below.

**TABLE 9. Pass rates and emphasis on English writing skills**

<table>
<thead>
<tr>
<th>Proportions passing</th>
<th>Emphasis on English writing skills</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very heavy or heavy</td>
<td>Little or no emphasis</td>
</tr>
<tr>
<td></td>
<td>% 1984 (N13) 1985 (N10) % 1984 (N23) 1985 (N21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower proportions of women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher proportions of women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower proportions of men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher proportions of men</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportions passing</th>
<th>Emphasis on English writing skills</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very heavy or heavy</td>
<td>Little or no emphasis</td>
</tr>
<tr>
<td></td>
<td>% 1984 (N13) 1985 (N10) % 1984 (N23) 1985 (N21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower proportions of women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher proportions of women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower proportions of men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher proportions of men</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The top of the class in first units*

The information presented in Table 1 shows that in both 1984 and 1985, women were somewhat less well represented than men at the top of the class in the first units.

In those courses with higher proportions of women at the top of the class in the first units, more importance was placed on the High School mathematics for the material covered (as distinct from aspects like the problem solving or mathematical proof skills). Where the first year of the course placed little or no emphasis on program coding skills, we observed that they also had fewer women at the top of the class. These findings are shown in the tables below.
TABLE 10. Top of the class in first units and importance of the material covered in High School mathematics for the students’ ability to cope with the course

<table>
<thead>
<tr>
<th>Proportion at the top of the class in the first units</th>
<th>Very important or important %</th>
<th>Little or no importance %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 (N15)</td>
<td>1985 (N10)</td>
</tr>
<tr>
<td>lower proportion of women</td>
<td>40 40</td>
<td>79 63</td>
</tr>
<tr>
<td>higher proportion of women</td>
<td>60 60</td>
<td>21 37</td>
</tr>
<tr>
<td>lower proportion of men</td>
<td>73 90</td>
<td>58 84</td>
</tr>
<tr>
<td>higher proportion of men</td>
<td>27 10</td>
<td>42 16</td>
</tr>
</tbody>
</table>

TABLE 11. Top of the class in first units and emphasis on coding skills in the first year

<table>
<thead>
<tr>
<th>Proportion at the top of the class in the first units</th>
<th>Heavy emphasis %</th>
<th>Some, little or no emphasis %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984 (N26)</td>
<td>1985 (N22)</td>
</tr>
<tr>
<td>lower proportion of women</td>
<td>50 54</td>
<td>91 75</td>
</tr>
<tr>
<td>higher proportion of women</td>
<td>50 46</td>
<td>9 35</td>
</tr>
<tr>
<td>lower proportion of men</td>
<td>73 64</td>
<td>45 92</td>
</tr>
<tr>
<td>higher proportion of men</td>
<td>27 36</td>
<td>55 8</td>
</tr>
</tbody>
</table>

We point out that the majority of courses do place a heavy emphasis on coding skills, the most basic and straightforward part of the programming process. Most of the courses that did not place a heavy emphasis on coding skills in the first year had a business rather than technical orientation. The effects we observed at the top of the class were far more difficult to interpret than those for other representational factors.

Top of the graduating class

Our questionnaire sought the number of students who completed the final year of the course in 1984 and the gender breakdown for the top of that class. We found that women constituted about a quarter of the graduating classes (see Table 1) and that there were proportionately more women at the top of the graduating class than men. We note that the response rates for this part of the questionnaire were small. Several courses had not yet produced any graduates by 1984 while others produced rather small numbers of graduates. We also found that the trend was by no means uniform.

It would appear that women’s lower representation at the top of the class in the first units does not apply later in the course. Overall, these data support the hypothesis that the very early stages of the courses pose particular problems for women.

Streaming

We were initially concerned at the consequences for women in courses where there was streaming at the very early stages of courses. In this sense, streaming refers to first units
with restricted entry and whose completion is necessary for entry to units offered later in the course. It appears, however, that no department runs a first unit that streams students in this way.

Although streaming at the beginning of the courses we studied is not a problem, a coincidence alerted us to another form of streaming. One respondent provided data for a first year unit that is a terminating unit. (Exceptional students, achieving extremely high grades in this course, can continue their computing studies.) This course had a higher proportion of women enrolled than was found in the first units of our study. We cannot generalise about women’s comparative representation in terminating courses from our one (accidental) case. However, several of the staff we interviewed volunteered that women enrolled in the terminating courses offered by their departments in higher proportions than was the case for the professionally accredited courses.

That higher proportions of women may be enrolling in such units may be of considerable importance for the concerns of this study. It would seem a useful avenue of future work to consider the difficulties and benefits of making it easier for students to migrate from terminating courses.

**Summary and discussion**

This section reported the basic distributive data yielded by the questionnaire on women’s representation and success at the early stages of the courses.

Our major findings on women’s representation in the courses in 1984 and 1985 are:

- women constituted about a quarter to a third of the enrolments in most courses;
- women outnumbered men three-to-two among those who discontinued by the 30 April in the first year of the course;
- women were slightly less likely than men to pass in the first units and
- there were slightly fewer women at the top of the class in the first units.

In addition, we found that in the graduating class of 1984, there were proportionately more women than men at the top of the class.

The overall representation of women is similar to that observed elsewhere for courses at this level. (Barron et al, 1985; Fisher, 1984; Gerver and Lewis, 1984; Miura and Hess, 1983; Zimmerman, 1983)

When we analysed those courses with higher than average numbers of women enrolling, discontinuing, passing and achieving top grades in the first units, we made the following observations.

In both 1984 and 1985, the proportions of women enrolling

- were higher for courses with a heavy emphasis on Information Systems and Data Processing, rather than Computer Science;
- were lower in courses where high school mathematics is considered very important for the problem solving and proof skills that it develops.
In both 1984 and 1985, we found that women’s early dropout rates

- were lower where mathematics bridging courses were run within the department, rather than somewhere else in the institution;
- were also lower in courses where no mathematics bridging course was available at all;
- were not related to the degree of emphasis on mathematics;
- were lower where remedial English assistance was available to students in their first year;
- were lower where there was emphasis on the development of English writing skills in the first year of the course and
- were not related to the orientation of the course.

In the case of the mathematical factors, similar, though smaller effects, were also observed for men in 1984.

Although we have noted that aspects of the mathematical emphasis in the course correlated with the proportion of women entering the course and the proportion dropping out by April 30, it did not relate to the proportions passing the first units or their representation in the top of the class. This would be explained if the differential effect of mathematics background were most significant at the earliest stages of the course.

In summary, our statistical findings suggest that there is a particular problem for women in the very early stages of the courses and that some aspects of teaching method, curriculum and course emphasis and orientation relate to better outcomes for women in these early stages of the course.

Before exploring the issues that we have identified as contributing to women’s representation and levels of achievement, we consider corroborative information from sources other than the distributive data of the questionnaire.

One such source was the student interviews which asked about the major problems that students had encountered throughout their course. A number of these related particularly to the beginning of the courses. Many derived from deficiencies in the students’ computing background, various alienating aspects of the course and their lack of confidence, matters that we will consider in greater depth in Section 3.

Some of the staff comments indicated awareness of and concern at problems that operated to disadvantage women particularly at the early stages of the course. These included observations such as these.

At starting levels, if the girls get through this well, they go on and do well, but the beginning is hard

Proportions of women drop from first to third year
Once the women get through the first year (those that do not drop out) there appear to be no further problems.

In general I believe that fewer women than men (proportionally) are achieving their true potential in our course.

I think that the initial difficulties I mentioned are true to a certain extent throughout the whole course, but much less severe in later years.

[Women experience] early lack of confidence with first programming unit - usually overcome as course proceeds.

A number of staff comments also suggested that women had a lower dropout rate than men after the early stages of the course.

In addition, several staff comments supported our rather tentative finding that women may be well represented at the top of the class by the final year.

[Women experience] no particular difficulties. Indeed many of our top graduates have been women.

In two out of the last three years, a returning, part-time "mum" has topped the course.

We should, however, note that these views were by no means unanimous. Several of the staff did not perceive any problems for women early in their courses or they took pains to distinguish between problems that were commonly experienced by women and those exclusive to women. In the next section, we present the issues that we identified as having a bearing on problems for women at the early stages of their computing studies. We emphasise that these are not exclusive to women and action to deal with them will undoubtably help many men too.

2. We use parenthesis to distinguish words we have added to make the context of the quotations clearer.
3. DISCUSSION OF ISSUES IDENTIFIED

The issues that we identified as significant in terms of women’s participation and levels of achievement have been grouped in three categories:

- those associated with the discipline itself;
- factors that are institutionally based and
- issues relating to individual interactions and perceptions.

Because the issues are inter-related, this division cannot always be tight. However, we have found it useful in that it defines the loci of potential solutions.

3.1 Issues relating to disciplinary skills and orientations

It is critical to identify those factors disadvantaging women and deriving from the essential nature of the discipline. We might expect disciplinary factors and perceptions of the discipline to influence students’ decisions to enter a course, to discontinue at the early stages and to affect their level of achievement. We also need to be particularly aware of potential mismatches between three views of the discipline:

- students’ expectations of the discipline;
- the nature of the discipline as it appears to students at the early stages of their studies;
- the broader nature of the discipline as it will be encountered by graduates of the courses.

In this section, we consider evidence of mismatches between the first and third of these views of computing. Other mismatches are considered in the section dealing with factors operating at the institutional level.

We begin by observing that computing is seen as technology- and machine-centred as well as strongly mathematically oriented. We examine aspects of these images that may affect women’s representation. In particular, we see indications that these aspects may be over-emphasised and that they may act to discourage women from computing studies. We also consider other less clearly perceived aspects of computing, including the importance of skills in communication and broadly based problem solving and observe that these important considerations tend to be underrated in the general image of the discipline. We also present evidence that these are areas in which women have strength.

Problem solving

There are two quite different interpretations of the meaning of “problem solving”: one narrow, the other broad. On the one hand, the term is used to describe the class of activity that mathematics students engage in when presented with a problem. Typically, this is tightly defined, the number of applicable techniques is quite small and the students’ task is to apply the appropriate one of these to get the answer. On the other hand, problem solving may involve broader, more loosely defined problems, amenable to many possible approaches several of which may give different solutions, that might be
evaluated in various ways. Both forms of problem solving are important in computing but the former tends to be easier to emphasise in courses in higher education, while the latter dominates the work of the professional.

There were indications that women do very well at problem solving in its broader sense which is often called the “systems” part of computing courses. This is illustrated in the following comments made by staff.

Women are very good at systems work and are, therefore, suited to the direction of computing to end user applications.

Women are good at “parallel processing”, that is thinking of many parts of a system simultaneously - comes naturally to women. [They are] intellectually, temperamentally suited to this - used to producing on time in the “real world” (eg at home or at work) and this is required in computing and system design.

Areas between systems analysis and theory suit women

Women do better in those subjects where communicative skills are emphasized, eg. systems analysis

[Women’s] interviewing skills and report-writing skills in systems analysis tend to be better

Numbers are very small but my impression is that systems analysis and design units are handled better than computer science and “technical” units

On the other hand, several staff also commented on women’s poorer problem solving skills. These comments appeared to refer to the narrower meaning and were often made in connection with mathematics courses.

Girls are not good problem solvers but the class as a whole is not very good at problem solving - they are better by the course’ end

A significant number of women have problems with programming concepts - difficulties with problem solving.

This is interesting in the light of studies (King, cited in Harding, 1983) which demonstrate differences in average performance by school leavers. These show better average scores for boys in tests of mathematics, spatial and mechanical skills but girls
have better average performance in *reasoning*, in both verbal and number areas.

*Mathematics*

The issue of mathematics arose again and again, in each component of this study. Mathematics is important to computing in the following ways:

- mathematics requires problem solving skills that are also important in the programming aspects of computing;
- mathematics involves formal manipulation of abstract symbols as do the programming aspects of computing;
- there is a considerable body of mathematical knowledge, as distinct from the skills described above, that is important in computing and
- there is a considerable body of computing that is very formal and mathematical in nature.

We observe that students entering a computing course with strength in mathematics might be better fitted for programming and the mathematical aspects of the computing courses. This has important implications for women since they tend to leave secondary school with poorer mathematical backgrounds than men. (Barnes, 1984; Gill, 1984) There is also evidence that students see computing and mathematics to be strongly linked and this affects their expectations of success in computing. (Kay and Prosser, 1984; Sanders, 1984)

There is, however, evidence to suggest that the link between mathematics and computing is not necessarily as strong or direct as it might seem. First, we consider findings from the questionnaire. When asked to rate the importance of various aspects of high school mathematics for their courses, less than half the respondents saw it as important or very important for the student’s understanding of the material covered. About half of the respondents saw it as important for the mathematical proof skills and sophistication within the course. High school mathematics was seen as much more important for the problem solving skills that the course required: only 6 out of 38 respondents viewed this aspects as being of little or no importance.

A similar picture emerges for the emphasis of mathematics in the first year of the course. The table below shows the degree to which the first year of the course emphasises two mathematical aspects, problem solving and mathematical proofs. To provide a context, we also show the emphasis on English writing skills. This indicates the importance placed on problem solving skills. It also shows that rather more courses place emphasis on English writing skills in the first year than on such higher order mathematical skill as that of mathematical proof.
TABLE 12. Emphasis on mathematical skills and English in the first year

<table>
<thead>
<tr>
<th>Skill area</th>
<th>Heavy emphasis</th>
<th>Some emphasis</th>
<th>Little emphasis</th>
<th>No emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving</td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>mathematical proof</td>
<td>5</td>
<td>10</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>English writing</td>
<td>6</td>
<td>16</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>

In staff interviews, there were comments about unnecessary emphasis on mathematics in computing courses. This was frequently linked to greater difficulties for women in computing courses. It is also consistent with our statistical findings.

**Hardware**

Hardware aspects of computing are concerned with the design and construction of the physical devices. The study of hardware is related to Electrical Engineering and has substantial overlap with that discipline. It appears to pose problems for women that might be likened to those experienced by women in Electrical Engineering. Here, as in the case of mathematics, women tend to leave school with less background than men. In addition, women tend to see this aspect of computing as particularly alienating. (Lockheed and Frakt, 1984; Game and Pringle, 1983)

Staff indicated particular problems for women in hardware aspects of courses with comments like this.

> Girls do not get hardware confidence in hardware units - these seem to alienate girls who rarely (never?) do higher level (optional) units; but girls should be able to do it well

> Some units have no women at all! Especially the hardware (optional) units.

> It seems there is a tendency for women to avoid hardware oriented sections of the course

> [Women do badly in] hardware/electronics units presumably due to lack of educational background at secondary schools level and all male teaching staff

Hardware constituted a tiny component of the first units; so problems in this area are not a major factor in our findings on the early stages of courses. By the final year of the course, it appears that women do well in spite of hardware units at that stage. However, this might be because the hardware units are optional and women may avoid them. Even among staff who noted that hardware material posed difficulties for women, there were no comments on how to address the problem. It is tempting to accept the view of the staff member who said,
hardware is not essential and therefore females need not be put off computing.

At the same time, it might be argued that it is important to students’ self-confidence that they feel able to cope with all aspects of the discipline, even if their own inclinations will not cause them to specialise in hardware. This view was offered in staff comments such as this:

women need to be given some idea of computer hardware - try to show female students that they control the machine

The hardware aspects of computing are probably the most machine-centred and staff comments indicate that most hardware units are optional. In addition, most computing professionals can survive with minimal knowledge of hardware. It would seem that this is one aspect of computing that is particularly alienating for women and yet, it is also one of the dominant images of the discipline.

*Communication skills*

Competence in communication, both spoken and written, is important for the majority of computing professionals graduating from the courses of this study. Women are traditionally seen to have strength in these skills. Staff noted the importance of such competence in comments such as these.

Women are more articulate. This is an advantage because of the emphasis on oral and written presentation and project work - (women) tend to be better at it

Women are more aware of interpersonal issues and overall do better at presentations

Women are on an even footing for writing and management skills

Women do better in those subjects where communicative skills are emphasized, eg. Systems Analysis

Interviewing skills and report-writing skills in systems analysis tend to be better [in the case of women students]

Women did less well on average in the computer science emphasis courses, and very well in the courses requiring interpersonal skills and reflective observation.

The existing technology-centred view of computing tends to under value such skills and to this extent, women may be unnecessarily disadvantaged.
3.2 Issues at the institutional level

This section covers those factors that appear to be largely based at the institutional level. Many can be tackled by individual departments and institutions.

The first of the issues relates to the ways in which institutions deal with student’s differing backgrounds. Although the focus of this study is on courses offered in the higher education sector, an appreciation of the effect of students’ varied backgrounds in computing and mathematics is important in defining appropriate teaching for the early stages of tertiary studies. We note that such differences can be addressed in three general ways:

- in the provision of “remedial” courses for students with less background;
- in structuring the first courses so that they cater for much of the typical range in student backgrounds;
- by excluding all students who lack the presumed background.

We saw evidence of each approach but consider that the findings of our study indicate the need for more effort in the first two ways of helping students who enter courses with a poorer background. Our study also indicates that such efforts should be tightly integrated into the early stages of the course.

A similar set of issues derive from the course emphases and orientation, especially as new students would perceive them. In this case, we consider various ways in which there are mismatches between the discipline and its image as projected to new students and the wider community, including many potential students.

Finally we consider matters related to the workload and level of resources and how these appear to affect women differentially.

Prior knowledge and experience in computing

It has been well documented that girls are likely to finish secondary school with less computing knowledge and experience than boys, both in terms of formal studies at school and informal learning activities on home computers and elsewhere. The matter has been reported in many countries, including the USA, Britain and in Australia. (Miura and Hess, 1983; Gribbin, 1984; Bakon, et al. 1983; Willis and Kenway, 1985; Kay and Prosser, 1983) Women are less likely to study computing at secondary school and when they do so, they are less likely to have undertaken programming or advanced computing studies. This poses problems, as Wilder, Mackie and Cooper observed:

... only learning a programming language increased females’ sense of computer competence. For males, any previous experience [of computing] increased their sense of competence.

Wilder, Mackie and Cooper, 1985:226
That lack of computing background caused problems at some institutions was noted in the student interviews at several institutions. From the considerable distance of their final year of studies, students were mindful of problems early in the course because they had less knowledge and experience of computing than was assumed. They recalled:

- a deep-end hands-on approach where students had no experience but were expected to have had it

- mystification of the discipline

- the use of jargon, especially in first year, was confusing

This is also a strong theme in a recent study undertaken at the University of Wollongong (Pirie 1986) where students in their first year were interviewed. Comments from those who had little or no computing background clearly indicate that they felt that this was a major disadvantage. The confidence shattering effect of a poorer computing background was also observed in a study at Melbourne University. (Johnston, 1985)

The handbook materials available for students entering the courses also appear to assume some computing knowledge in that they make extensive use of jargon. It would seem that the student who could at least understand these materials might be at some advantage.

Some staff perceived the differences in women’s initial knowledge and experience as the following comments indicate.

- Girls generally know very little at the start - men are more experienced and confident than women.

- Girls are not encouraged at school to pursue careers in scientific/mathematical/computing areas.

- Women tend to be less familiar with computers because they don’t play with computers or get access to them in schools as much as boys do.

- Women sometimes do not have the same background of school subjects as men and may therefore be disadvantaged and need to spend more time on a subject to catch up.

- Boys have had more experience of computers at point of entry. When girls arrive, they see boys take to it easily
Boys straight from school who were computer hobbyists are a little bit let down by the first year course - they have to go back to basics - [we] try to give extra lab exercises to these boys.

The last comment is particularly interesting: it would seem that students who enter with a strong computing background might be assumed to be male.

Although some staff saw the lack of computing knowledge as a potential disadvantage, some expressed the opposite view, in these terms.

Guys have more experience with micros and have more to unlearn;

This may well be so, but there is evidence that previous experience is an advantage, especially at the early stages of the course. Certainly this is a strong theme in the study of Computer Science students at the University of Wollongong (Porter and Pirie, 1986) and it was observed for the first units at the University of Sydney (Kay and Prosser, 1983) as well as in the USA. (Konvalina et al, 1983)

As the following comment indicates, some staff saw little difference in the women's and men's previous knowledge or experience in computing, or attributed little significance to any they identified.

Women and men are equally disadvantaged for first course or months if they have not studied computing. After that, the ones with no prior experience catch up.

That differences in experience make little long term difference for those who complete the course is supported by a detailed study of first year students at the University of Sydney (Kay and Prosser, 1983). In this investigation, achievement in the first units did correlate with previous programming experience but by the end of the first year it did not. It would seem that students who were still enrolled by the end of the first year had overcome difficulties that were due to weaker computing backgrounds. However, this observation, and the staff member quoted above ignore those students who do not survive the early stages of the course. Such a view also ignores the effect of differing prior knowledge and experience, particularly at the early stages of the courses.

From work done in Britain (Barron et al, 1985; Allison pers. comm.) and the ACT (Collings pers. comm.) we also note that the proportion of women entering computing courses has been observed to drop in parallel with the increased teaching of computing in schools. Such observations suggest that the computing experiences at secondary level do not serve to encourage girls to continue their computing studies. Further, expansion in the teaching of computing in schools may not redress the problems arising from differences in women's knowledge and experience of computing as they enter tertiary courses.

At this point, it is appropriate to note that problems of this type which particularly affect women may be readily overlooked by staff, since women are a minority in the courses and students with less background may not be very visible to the teaching staff.

22
Background in mathematics

We have already discussed some aspects of the importance of mathematics for computing and noted that women are more likely to complete their secondary education with less mathematics. In Section 2, we observed that women’s representation related to aspects of the mathematical emphasis of courses and the availability and location of bridging courses. It may, therefore, be seen as an institutional responsibility to assist students who are accepted for the courses when they lack the required level of mathematical background.

In interviews, several staff distinguished between women’s ability and background or performance in mathematics.

- Women have lesser performance in maths and problem solving due to lesser maths background and social stereotyping

- No difference in maths ability - suspect women don’t have as much depth [in their mathematical background]

- Females make up the larger percentage of students, with weakness or lack of confidence in logic and math skills, who do encounter difficulties

- The [unit name omitted] draws heavily on logic and "mathematical" approaches. In general, the confidence of women in handling this material is less than that of the men.

This is consistent with the view that sex differences in mathematics achievement are socially, rather than biologically determined. (Erickson and Erickson, 1984; Harding, 1983) The observations quoted below highlight the problems that follow for students with a weak mathematics background. They gloss over the responsibilities that lie with institutions which accept students lacking the presumed mathematical skills.

- Those students who have weaker mathematical backgrounds have greater difficulty in the mathematics units.

- Mature women clearly find the maths a problem, but all managed to come to terms with it.

One comment from a staff member raises a number of other issues on the matter of mathematics in computing courses.

- Computing is bound into maths and stats - I don’t see the need for so much maths.
This discriminates against girls. [The students] need reasoning ability, but they don’t need HSC maths. Course is taught by maths applications. Common sense is more important. Logical reasoning is not derived from maths.

This staff member expresses concern at problems generated by the unnecessary use of mathematical examples and applications in illustrating concepts and in practical work. Often, the same concepts could be discussed in terms of non-mathematical examples. It is the mathematical background of staff that makes mathematical examples seem the most natural and obvious to them.

School mathematics performance has been observed to correlate with success in computing courses. (Kay and Prosser, 1983; Konvalina et al, 1983) Other factors, including overall high school achievement, also correlate with both success in computing and high school mathematics achievement. Indeed, the studies cited above observed that overall high school achievement was also a good predictor of computing success.

**Course structure**

Course structures define the material that is covered, the order in which it is treated and the emphasis. If courses are to alter the way in which they deal with the range of educational backgrounds among students they accept, the early parts of the course may need to be changed.

Staff we interviewed saw such changes as part of the approach to helping women and men with weaker computing and mathematical background. Some suggested altering the order of presentation so that systems and problem solving were given more emphasis at the early stages.

The point at which the study of hardware and computer architecture is introduced appears important. However, staff comments on this matter were inconsistent. On the one hand, it was suggested that the study of hardware should be included early in the course to allow students with less hardware experience to confront, and come to terms with this aspect of the discipline early in the course.

women need to be given some idea of computer hardware - try to show female students that they control the machine

Introduce some discussion of computer architecture into the course - brought forward the introduction to computer technology - [this proved to be] good/successful.

[We could help women by] teaching some hardware explanations early in the course.

This approach may well be useful for students who survive the early stages. On the other hand, several staff comments suggest minimising the importance of hardware in the discipline or moving its study to later in the course so that students with little prior
knowledge need not be alienated unnecessarily. This view is supported by the following comment.

Get hardware into second semester, not a starting unit.

The best timing for the introduction of these aspects of computing needs further consideration.

Another group of comments suggested the introduction of streaming. This proposal was generally directed at the most able students and the need to stimulate and challenge them. The logical corollary is streaming to develop the fundamental skills for students with weaker mathematical or computing backgrounds. The form of streaming that most staff suggested was to offer additional assignments and to stream the small group teaching.

Some staff suggested that an overview of the discipline should be presented early in the course. Such an overview would set the technical material treated in the first year in a broader and integrated context. Harding (1983) presents evidence to suggest that this would make the courses more appealing to women.

Other comments stressed the value of a greater emphasis on broad problem solving, or systems, at the early stages of the course. For example:

Get systems as introductory unit, in parallel with programming; get an overview first; make first programming unit more conceptual, eases the "jargon" and "familiarity with micro-computers" load.

Limited computing resources and heavy workload

The problems of limited computing resources and heavy workload are treated together because they interact very strongly. Such problems were consistently reported in the student interviews. This was true across all the institutions for both women and men. The appearance of gender neutrality of these problems can belie the reality: for example the need for late night work poses special difficulties for women. Gender bias aside, the problems are so pervasive they deserve attention.

Some of the difficulties that students identified in this area were described as follows:

getting access to terminals or machines

wasting time waiting for a free terminal

hardware always down

having to work very late at night on campus (after mid-night) and difficulties in
getting late night transport home

waiting on a machine that was slow because it was overloaded

heavy workload (compared to other disciplines)

need to spend hours getting a programming assignment right

no chance to relax

too little time for family and social life

As we have noted, both women and men complained of these problems. These were final year students, who had persevered with their studies. When we consider the students who did not persevere beyond the very early stages of the course, the matter of workload and shortages of resources takes on a different light. It has been well documented that at the secondary level girls are less willing than boys to fight for terminals (Willis and Kenway, 1985) and this might well apply to women at the very beginning of their higher education studies.

Although complaints about needing to use the computers late at night were made by both women and men, it could reasonably be seen that this poses a particular problem for women, for whom there are more problems in staying on campus very late. This view was proffered by several of the male members of staff interviewed. They saw late laboratory hours and the need to compete for scarce resources as disadvantages particularly for women.

Some staff suggested that problems related to scarce resources might be mitigated by expected improvements in the technology as this could make it feasible to do assignments at home, thereby obviating the need to work on campus late at night. It would also avoid the competition for computing resources. However, should there be an associated financial burden to be borne by the student, we might be concerned that this would relatively disadvantage women because it appears that parents are less willing to provide financial support for their daughters. (Powles, 1986). It could also be expected to have negative consequences for students who are financially disadvantaged.

3.3 Issues at the level of the individual

Earlier sections dealt with matters deriving from the nature of the discipline or principally associated with the institutions. The issues described in this section relate to student and staff perceptions, assumptions and stereotypes and the attitudes and behaviours which follow.
Although we have observed particular problems for women in the computing courses we studied, we would not wish to suggest that the problems we have discussed apply exclusively to women or that these problems are common to all women. Indeed, this is not so.

However, many of the difficulties that women experienced in their computing studies have some basis in stereotypes of women. In this section, we examine the stereotypes of women and men projected in staff and student interviews and in comments at the end of the questionnaire. They concern students’ approaches to their studies, learning and problem solving. We explore something of the positive and negative aspects of these stereotypes in terms of attitudes towards women students, the ways in which the students interact with staff and other students and the differing attitudes of women and men to computers.

Stereotypes

Our interviews of staff and students helped identify some widespread assumptions about women in these courses. Most of these are double-edged in that they can be viewed positively, negatively or both. Consider, for example, views of women’s strengths and related weakness as programmers.

Several staff made comments to indicate strengths of women which should make them good programmers. These included such qualities as being more methodical, meticulous, thorough, conscientious, well organised, neat and patient. Typical comments included the following.

- Women do better in programming - more methodical, document better, test more thoroughly

- Women do better in [subject name omitted] and subjects requiring meticulous work

- Women tend to be better organised in their study habits

- Women study more consistently

- Women are more patient, especially in abstract areas

- Women are good at detailed work - more meticulous than men

- Girls go home and work on printouts before trying again - men tend to sit down at terminals straight away
While this might be interpreted as depicting a positive stereotype, there was more than a hint that women are pedestrian workers, rather than the high flyers. Indeed, this view was expressed by several staff who felt that women fulfilled the defined requirements and did what was asked of them, but no more than that.

Girls hold their own on doing set tasks

Women are more interested in immediate problems they had with the machine, men have more overall aim

Men ... attempt more than required. Girls perform better on what is asked of them.

This stereotype has another negative side in that it suggests that women’s grades might overstate their true knowledge and skills compared to men. It is also an instance of damning women for doing exactly what is asked of them. In summary, this stereotype suggests that women are more diligent workers but it depicts women as lacking imagination and being plodders.

Another stereotype concerns the matter of confidence. Women were seen as timid, less confident, less experimental or adventurous and more likely to ask for help with problems than to work them out for themselves. By contrast, men were seen as confident, adventurous, assertive, self-reliant and inclined to experiment. Several staff made comments confirming a model of men as attempting more than was required, gaining greater insight and solving problems by exploration. Typical comments included these:

Guys explore and experiment and muck around to discover how to make things work whereas girls ask or get stumped by the machine

Men are more adventurous

[Women have a] lack of confidence in approaching machines compared with male counterpart. The small number of women in classes tends to accentuate the above problem especially where there is competition for equipment

The same gender-split on exploratory behaviour has been noted at the secondary school level. (Willis and Kenway, 1985; Moont, 1984)

A third class of stereotypes concerned independence and self-reliance of students. This relates to the other stereotypes and depicts women as being relatively dependent, seeking help rather than working problems out alone.
Some women do not work independently - that is they get assignments done by male students and tutors.

“Helpless female” procedure done by a few girls.

The same sentiments were expressed by a few of the students interviewed, where some of the female students admitted to having played this role. This also matches the observations of women’s “learned helplessness” in mathematics (Leder, 1981) and science (Harding, 1980).

This is a particularly dangerous stereotype as it acts to downgrade women’s achievements on the grounds that their results may not be viewed as a true reflection of their own work; there may even be a suggestion of cheating. Yet another danger of this stereotype is that it excuses bad teaching; it allows teachers to blame the students who need to seek such assistance.

Another view of women emphasises their lack of confidence compared to men. This, and its detrimental effects, have been observed elsewhere. (Williams and Pepe, 1983; Carpenter and Western, 1982) Given that women are likely to have less computing background on entering the courses, one might well expect them to lack confidence as the following staff member’s comment suggests.

Greater number of males have used computers in secondary school or/and home, therefore more at ease and confident

One might expect such effects to be most critical at the very early stages of the courses and several staff observed that women lacked confidence most in the early units. A typical comment is:

Early lack of confidence with first programming unit (usually overcome as course proceeds)

One student interviewed made a telling observation that this is an advantage for women doing computing because:

women expected to fail and it is therefore easier to succeed - less pressure

Staff also commented on lack of confidence and that women were more likely to internalise failures. Observations included the following:

[women suffer] timidity when faced with equipment - if a male finds equipment not working he swears but a woman tends to blame herself

Women seem to have a low self-image
Women have lower aspirations/expectations

In the section where we discussed disciplinary issues, we commented on stereotypes attributing particular skills to women in inter-personal relations and written and spoken communications.

Together, these images portray the “typical woman student” as timid, lacking self-confidence, having low expectations, being a hard worker, who is good at dealing with and communicating with other people. The views we have described above were not expressed by all the staff interviewed: several did not see that women experienced any special problems.

Interactions between students and staff

Another side of the tyranny of stereotyping was noted by several staff who commented on the need for staff to be encouraging and positive in dealing with women.

The statement "No girls ever finish this course" is negative reinforcement.

In early group work, train staff on how to deal with girls as students, encourage them to be leaders etc. Train staff to see their own prejudices.

Many staff members, both women and men, saw a variety of ways in which women students would be advantaged if there were more women on teaching staff. They suggested, for example, that female staff might serve as role models and mentors for women students. Some typical comments were:

The only bias in this department is the total absence of female academic staff. This may affect student-tutor relationships in individual cases (with female students reluctant to consult with male staff)

Some women lack assertiveness and if they have a male tutor get little encouragement; female tutors are better at encouraging female students

In addition, staff expressed the view that all students would gain from the presence of more women on staff since it was felt that women were often better, more caring teachers.

Have a lot of women tutors, less threatening to all students.

Interestingly, data from the questionnaire did not show any increase in women’s participation or achievement in first units that had more women teaching them. It may be that we failed to observe an effect because all the courses we studied had quite small numbers of women on teaching staff. We have some indirect evidence that women staff might be more concerned about the issues that this study addresses in that women staff
that we interviewed had consistently more comments on all aspects covered in the interviews.

That women constitute a distinct minority on staff and within the student body causes a number of problems. In particular, it is easy for staff to be less aware of the needs of a minority as the tone of the class is largely defined by the majority of the class. For example, in a class where the majority of the students have some computing background, it is easy for the staff to be unaware that all the students who had no background are experiencing difficulties. This problem was described in the following comment from the questionnaire.

Women are fewer in numbers ... therefore they get less overall understanding and support.

The problem is further compounded when students in the minority feel unable to express their views. Several comments from students and staff suggest that women, in particular, suffer in this way. One such comment is:

Women don’t speak up - that is bring themselves to the attention of staff. Boys do this; ask questions in class. Girls wait till class is finished then come up to ask.

**Interactions between students**

We have already discussed some of the effects of stereotypes on student interactions. In particular, staff and students both observed the use of “feminine wiles” by women who needed assistance in their assignments.

Yet a staff member commented:

In situations where a terminal is shared it is my observation that, where men and women share, the man tends to take control to an extent, in doing the typing etc.

This effect could be taken into account in design of the early stages of the course.

Quite another type of problem arises from the fact that women students are a minority in computing courses. A male staff member observed some of the these effects.

I’m sure that if we had more women they would tend to feel less threatened through greater mutual support. The male technocratic ethos is appallingly powerful.

This comment highlights two of the alienating aspects of the courses: the predominant student attitude to the discipline of computing and the role of groups. Several staff members commented that students who worked in groups were at a major advantage and some noted that group work was officially recognised and supported in their institutions which provided space and encouragement for students to work together on their practical assignments. Several staff noted that women “stick together” and support each other in groups:
A couple of pairs of women stand out in memory [in that they] work together, support each other

Women [have] very cohesive groupings

The following comment suggests that there may be a need for such groups:

Lack of self confidence in a male dominated group.

One staff member commented that people who failed to form groups were at a significant disadvantage. He saw women as less likely to work in groups.

[I have] observed that groups of males form syndicates around terminals, women tend to work by themselves. If groups are operating it can be a disadvantage if a student is not in a group - groups hog terminals, cooperate in getting assignments done.

We might reconcile these views and our other findings by postulating that women being a minority may less able to form peer groups at the very early stages of the course, though the same minority status may promote the formation of cohesive groups at later stages. This view is consistent with observations by Williams (1975) who describes the problems of isolation for some students in large classes.

Given that much of the computing professional’s work requires co-operation in a team, we might expect that courses could encourage students to form groups and work collectively.

Technology centred attitudes to the machine

The notion of technology centredness has been highlighted by Papert (1985) to capture a view of computing in which the machine is the focus. By contrast, one can take a problem- or people-centred view of computing. Then, the computer and related knowledge is seen, not an end in itself, but in terms of how it might be used to help people in dealing with problems.

Much of what happens in the computing courses covered by this study is technology-centred. In a general sense, this is perfectly appropriate: the development and research in computing is concerned with the technology. Further, the technical aspects of computing are the foundations which computing professionals use and that technological base is essential for the application of computers; it defines the extent and the bounds of what is possible. Further, Beswick and Boreham (1983) found that students studying in areas like computing are relatively less interested in being able to work with and help people. On the other hand, most computing professionals have extensive dealing with people and issues that are centred on people. Harding (1983), Head (1979 and 1980) and Omerod (1971) cite evidence to suggest that women tend to be less technology-centred than men. This view was supported by several of the staff interviewed.
Clearly, individuals exhibit considerable differences in the degree to which they are technology-centred. At one extreme is the hacker, an individual who devotes a great deal of time to playing with the computer. The hacker may attempt anti-social activities like breaking the security of the system. It seems that only men are hackers. (Gerver and Lewis 1984) This was also noted in our student interviews and in staff comments such as these.

Guys tend to be hackers - women are not hackers

Girls don’t see it [hacking] as recreational

Girls have never been cautioned about abusing the system.

Lockheed (1985) observes, as did some of the staff interviewed, that men generally use and like computers more than women do.

Listing the positive attributes of the hacker, we would include detailed technical knowledge, curiosity and an exploratory approach. It would seem that the staff we interviewed regarded these positive attributes as being more common among their male students.
4. INTERVENTION

This component of the study was undertaken in parallel with the other aspects. Although it did not develop out of the findings of this study, it is based on the findings of the earlier study at the University of Sydney in which several of the same issues arose.

Two approaches were investigated: an orientation programme and a programme to establish a support group for women. Both addressed the problems of women at the early stages of the first year of the course.

4.1 Orientation programme

The orientation programme aimed to provide three main forms of assistance to students:

i. an orientation to the course and the campus, with a chance to meet other students and staff, so that they would feel that they had support from these people;

ii. greater confidence about what would be expected of them in the Computer Science course and, hence, a better idea of how they would cope with it;

iii. some material that would assist them in the Computer Science course.

The orientation programme was run before the first lectures of the first Computer Science course at the University of Sydney. We had observed that many of the students who come from less technically oriented faculties and those who have difficulty with the course also suffered isolation within it. They could spend several months of the course in the company of 800 fellow students without coming to know any one of them well enough to ask for copies of lecture notes or to be able to discuss the practical work. We viewed this as a significant disadvantage (as did staff interviewed at several other institutions). The programme gave students the opportunity to meet each other and some of the staff as well as giving them a headstart to learning their way around the campus.

In addition, we wanted participants to appreciate that computing requires problem solving skills and we tried to achieve this using a paper-only study of a pre-programming language, Karel. (Pattis, 1981) Although it is possible to use a machine implementation so that students can actually run their Karel programs, we used the paper-only approach for two reasons. Firstly, we wanted to emphasise the problem solving and program design aspects of programming, rather than the mechanics of typing up programs and running them. Secondly we did not want to duplicate material covered in the Computer Science 1 course.

The orientation programme was advertised to students enrolling in the University for the first time. We defined selection criteria to identify students who had

- HSC aggregates in the middle of the class range,
- mathematics backgrounds that were in the lower half of the class and
- little or no computing background.

Of the students who met the criteria, we randomly selected 14 women and 14 men.
The orientation course took the form of four intensive days of work preceded by a brief welcome, a lunch, distribution of materials to the students and an overview of the academic content of the programme. This provided an informal start where students could talk to each other and the staff involved in running the course. On each day of the course, the morning was spent in formal sessions. The afternoons were for private work with a tutor available to provide assistance. On the afternoon of the last day, the participants were given access to a computer to run some demonstration programs.

4.2 Description of the evaluation

Students were surveyed before and after the course. Both surveys asked students about their knowledge of computing, their anxiety about the Computer Science course, their ability and enjoyment in mathematical problem solving tasks and how important it was for them to do well in Computer Science 1. The after survey additionally asked whether they had found the programme helpful and about the importance of the various components.

The second form of evaluation was based on interviews of students at the end of the year. We asked what the students remembered about the course in general, how useful and how relevant they thought it had been. We then asked them about particular aspects of the course, including the social aspects, both in meeting staff and students, help in problem solving, as an introduction to Pascal and finally we asked what the most useful aspects of the course were and how it could be improved.

Outcomes

The major outcomes from the student’s perspective related to the course content whereas the staff saw the social aspects as the most significant.

Twenty-one of the 26 students rated their initial knowledge of programming as nil and all 21 increased that rating by the end of the orientation programme. It also seems that students may have become less anxious after the programme: ten students gave a lower anxiety rating in the after-survey and three gave higher ratings. The after-questionnaire also indicated that the students found the course helpful. In open-ended comments, nine students indicated that they had developed confidence about enrolling in CS1, eight noted that it helped them develop understanding and six felt that they had acquired problem solving skills. There was no mention of the social aspects.

Two main findings emerged from the end of year interviews. Four of the twelve students interviewed had trouble seeing the relevance of the content of the orientation programme for the CS1 course. Secondly, eight of the twelve had found good friends as a result of the programme.

In summary, the programme appeared to provide some pre-programming skills, although it needed to be more tightly integrated to the course proper. It also appeared to have met the other two objectives, enhancing confidence and helping students feel less isolated.

Because this was a pilot programme, run with a select group and considerable resources, we cannot extrapolate directly from it. However, we consider its success justifies investigation of a similar orientation programme that is run as the first part of a course.
Support group

The second form of intervention that we attempted was to assist in the establishment of a support group for women in the course at Sydney University. The programme was run outside the computing department, by a member of the Centre for Teaching and Learning. It involved a non-task oriented group that met voluntarily to discuss aspects of university life and their computing studies.

In the event, this approach failed, although we did attempt it three times, in first and second terms of 1985 and in first term, 1986. It is useful to consider some of the possible reasons for its failure. These include: insufficient integration with the remainder of the course; poor timing within the year; poor timetabling options that were available; and the heavy workload of the students.

In spite of the failure of this approach, some of the women who attended indicated that there is a need for such a group. It would seem that with pressures of student workload in computing courses, a tighter integration with the course is necessary to sustain a group.
5. SUMMARY AND CONCLUSIONS

The principal concerns of this study have been to investigate women’s representation in professionally accredited computing courses. We consider the degree to which women are drawn to these computing courses in the first instance, whether they continue their enrolment and how well they achieve academically at the very early stages and at graduation. We have sought to identify factors contributing to explanation of the patterns of participation which have emerged.

The following dialogue from Hawkins (1985) provides incisive comment on the social backdrop for this study.

Interviewer: What was the reaction from people when you became interested in math and then later computer science?

Nancy: Well, my math professor thought it was great, of course. My parents didn’t think it was such a great idea. As far as my career was concerned, my father did not like the idea too much. He did not think it was a good field for a woman to be in.

Interviewer: Did he say why?

Nancy: Well he considered computer science to be very engineering-like, I don’t know why really. Maybe too hard, and maybe because it wasn’t English. And maybe also cause he thought my chances of getting a job would not be too good. My mother never understands what I’m doing. She doesn’t understand computers at all.

Hawkins, 1985:165

It highlights some commonly held assumptions on sex roles and consequent expectations of behaviour.

In brief, we observed that in the professionally accredited courses we studied

- fewer women than men enrolled; women were usually between a quarter and a third of enrolments;
- women were more likely than men to discontinue in the first months of the course;
- women were relatively less well represented than men at the top of the class in the early stages of the courses.

The difficulties that particularly beset women appear to have most impact in the early stages of the course as, in 1985 at least, proportionately more women than men achieved grades at the top of the graduating class.

As well as this basic distributive information, and indeed tied to it, we observed relationships in the patterns of women’s enrolment, early dropout and achievement. For example:
• women appear to be more attracted to courses emphasising Information Systems and Data Processing than to Computer Science courses;

• fewer women are attracted to courses in which greater importance is placed on high school mathematics for the development of skills in problem solving and mathematical proof;

• the dropout rate for women, the proportions of women passing the course and their representation at the top of the class in the early stages of the course did not appear to relate to an emphasis on mathematics.

Our investigations suggested that explanations for these findings could usefully be explored at three levels:

• in terms of the discipline itself;

• in the role played by the institutions in the way that they structured and presented the courses;

• and in terms of the perceptions, attitudes and interactions of individual students and staff.

Probing these three dimensions, we identified a series of variables which serve to discourage women from enrolling in computing courses. The variables do not operate independently, but rather they interact and reinforce each other. While this three-tiered model is analytically useful since it indicates points at which change might be implemented, the reality is less simple. The attitudes of individuals, for example, may both reflect the character of computing and serve to reinforce this image. Similarly, what an institution presents as important in its computing courses is influenced by what is accepted as the nature of the discipline. Thus the view of computing as technology-centred and mathematically-oriented is likely to influence the structure, the content and presentation of courses, thereby recreating that image for staff and students. It takes a questioning re-appraisal to break with conventional values.

Our findings indicate that many of the problems women experience relate to the traditional female and male roles and to commonly held views of computing. Stereotyping gender roles circumscribes the aspirations and expectations of students and potential students in these courses. Equally, they affect staff in their dealings with students. Computing is commonly seen and presented as heavily technology-centred and reliant upon mathematics. Not only are these classes of knowledge and orientations that have been traditionally and formally less accessible to women but their importance to the discipline is frequently overrated.

In this context, our findings on women’s representation and achievement in computing courses are not surprising. If we also take account of women’s typically lower levels of confidence and the ways that this interacts with a relatively impoverished background in computing, technology and mathematics, the causes for our findings become even clearer.

It is important to note that the problems we have identified as particularly affecting women are not exclusive to them. In all the matters we have discussed, both women and
men display a wide range of differences. Changes which address issues that appear to have an impact on women’s representation should help all students.
6. Acknowledgements

This work would not have been possible without the assistance of the contacts and survey respondents in each computing department. Many of them devoted considerable time to extracting statistics that were not readily available and supported this project in many other ways.

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7. APPENDICES

APPENDIX I - GLOSSARY OF TERMS

The following definitions have been used throughout the report.

Computing

This is used as a general term to cover Computer Science, Data Processing and Information Systems. We use it to refer to all the courses covered by this study.

Course

This refers to the full sequence of computing studies leading to an accredited qualification.

Unit

This means a course component for which a grade is given.

Participation rates

The term participation is used to refer to the proportion of women doing the computing courses. Because our study focuses on the very beginning of computing courses, we use participation to mean all of the following:

- the proportion of women entering the course;
- the proportion of women still enrolled at April 30th in the first year of the course;
- the proportion of women passing the first units of the course;
- the proportion of women in the top 10% of the class, for the first units;
- the proportion of women in the graduating class and
- the proportion of women in the top 10% of the graduating class.

Systemic discrimination

Systematic discrimination is the combination of all forms of discrimination, whether direct or indirect, wilful or unconscious decreasing opportunities (for women). Further, it includes the inevitable negative attitudes which women develop towards themselves as a result of contracted opportunities (Davies B., “Disrimination, Affirmative Action and Women Academics: A Case Study of the University of New England”, Vestes 25, 1982:16).
This study was motivated by a concern at the lower participation rates of women in computing courses. Over several years we made the following observations about the students at Sydney University.

- About 25% of students enrolling are women.
- Women are over-represented among those who discontinue from the first year course both before the time that they are formally regarded as discontinuations and afterwards.

A more detailed study of the 1983 class (Kay and Prosser, 1983) led to the following findings.

- People who discontinue may, nonetheless, have backgrounds which are essentially similar to many students who succeed in this course.
- Women appear to be underachieving in Computer Science courses. This trend is particularly pronounced in the courses that demand problem solving skills and in the gender balance at the top of the class. (This trend is most notable in the top 10% of the class.)
- Introduction of streaming (so that students can elect to attempt quite challenging problems) may further reduce the number of women among the top students in the class.
- Whilst HSC results appear to be the best available predictor (of wide applicability) for success in Computer Science, there is evidence that a substantial proportion of students with low HSC aggregates attain good results in Computer Science and this effect appears to be more pronounced for women.

When these findings were discussed with staff at other computing departments, we were consistently told that other institutions were quite different; these staff felt that their classes had more nearly equal numbers of women and that women in their courses did just as well as, often better than the men. A common view was that computing is a new field and there are few bars, if any, to women’s entry and success within it.
APPENDIX III - LIST OF COURSES COVERED BY THIS STUDY

- University of Adelaide, BSc, BA (Comp. major)
- Australian National University, BA, BEc, BSc (Comp. major)
- Ballarat College of Advanced Education, BAppSc, BBus
- Bendigo College of Advanced Education, BAppSc, BBus
- Brisbane College of Advanced Education, BBus(DP)
- Canberra College of Advanced Education, BA, BAppSc (Comp. major)
- Capricornia Institute of Advanced Education, BApp Sc (Maths and Comp)
- Chisholm Institute of Technology, BApp Sc (Comp)
- Darling Downs Institute of Advanced Education, BBus, BAppSc (Comp. major)
- Darwin Institute of Technology, BBus(DP)
- Deakin University, BSc, BA, BComm (Comp. major)
- Flinders University, BSc, BA (Comp. major)
- Footscray Institute of Technology, DipAppSc, BAppSc
- Griffith University, BInf
- La Trobe University (Comp. major)
- Macquarie University, BA, BSc (Comp. major)
- University of Melbourne BSc, BComm, BA (Comp. major)
- Mitchell College of Advanced Education, BBus (DP major)
- Monash University, BA, BSc, BEc (Comp. major)
- Murdoch University, BSc (Comp. major)
- Nepean College of Advanced Education, BBus (Comp. and IS major)
- University of Newcastle, BA, BMath, BComm, BEc, BE (Comp. major)
- University of New England, BA, BSc (Comp. major)
- New South Wales Institute of Technology, BApp Sc (CS or Maths)
- University of New South Wales, BSc, BE/BSc (Comp. major) BComm (Acc and Inf systems) BSc and Inf Sys
- Queensland Institute of Technology, BBus (Comp)
- University of Queensland, BSc, BA, BEc (Comp. major)
- Royal Melbourne Institute of Technology, BApp Sc in CS
• South Australian Institute of Technology, BApp Sc in Computer Studies
• Swinbourne Institute of Technology, BApp Sc, BBus (DP)
• University of Sydney, BA, BEc, BSc (Comp. major)
• University of Tasmania, BSc, BA, BComm, BEc (Comp. major)
• Victoria College, BBus (Comp)
• Western Australian Institute of Technology, BApp Sc(Maths & Comp), BApp Sc(Comp Technology), BBus (Inf Proc)
• University of Western Australia, BSc (Comp. major)
• University of Wollongong, BA, BSc, BMath, BComm (Comp. major)
APPENDIX IV - METHODOLOGY

Large scale questionnaire

This was a survey of all Australian computing courses leading to a professionally accredited qualification. It sought enrolment figures in at various points in the courses in order to give a broad picture of the representation of women

- at the very beginning of the courses,
- by the end of the first units in the courses,
- among the graduates of the courses and
- in the group of students who were in the top ten percent of the class.

To assist in the interpretation of this data and to set a context for it, the questionnaire also collected the following information about each course:

- the criteria used for selection of students;
- the major emphases of each course;
- the importance of various pre-knowledge and skills;
- the emphasis given to various skills that are commonly part of the first year of computing courses;
- the assistance available to students who experience difficulties in the early parts of the course and
- the views of respondents on particular problems, advantages or disadvantages that apply to women in computing courses.

In view of the fact that much of the data that we sought was not readily available, we sought a contact person at each institution. In a sense, those contacts should be considered as part of the project team; several of them have a strong interest in the subject and they not only gave considerable time in collecting data but several of them took the initiative in providing additional related information.

Selection of participating institutions

This survey was sent to all the departments which offer a course that had ASC qualification level 1, or seemed to be approximately equivalent to that level. This selection needs some justification. The ACS, Australian Computer Society, is the professional society for computing specialists in Australia. It accredits courses at levels one to three and the level of accreditation defines how many years additional experience a student needs before being eligible to be a full member of the society. So, for example, a student graduating from a level 1 accredited course, needs to have four years of industry experience at an appropriate level in order to become a full member of the society. Students with a qualification at a lower level need more professional experience.

At the time that we started our study, the most recent list of accredited courses was issued in April 1983 and even in that, a fair proportion of courses listed had only been given
provisional accreditation, subject to further investigation. This investigation takes some time and so accreditation lists are consistently out of date with the true state of courses being offered.

In view of this problem, this study constructed a list of participating institutions in the following way. In order to ensure that the majority of courses which have either level 1 accreditation or are equivalent to that level, we created a list from the ACS list and we supplemented this, using the 1983 Higher Education Handbook and the mailing list of the Computer Science Professors Association.

As far as possible, we believe that we have included all courses from the 1983 Higher Education handbook that are at, or equivalent to the ACS level 1 of accreditation. The ACS requires a certain duration and content within accredited courses. In general, it requires a course of approximately three years duration and with particular material covered in order to qualify for level 1. Clearly we did not have the resources to duplicate the ACS accreditation process. Instead we included courses of three or more years duration and appearing to have a similar amount and type of computing content to that of courses we know to have level 1 accreditable. When in doubt, we have erred on the side of generosity in assuming level 1 accreditation.

Analysis of the questionnaire

Although the focus of this study is women’s participation rates, we felt it was important to be able to compare the outcomes we observed for women against comparable ones for men. So, for example, when we consider the early drop out rate for women, we consider the number of women enrolled at April 30th compared to the number who initially enrolled. We also calculate the comparable ratio for men.

To determine women’s relative levels of achievement, we considered several measures:

- the number of women who pass the first units, compared against the number who were enrolled in those units at the 30th April and we compare this against
- the comparable ratio for men;
- the number of women achieving marks within the top 10% of the class in the first units, compared to the number pass and this too was compared against
- the same ratio for men;
- the number of women in the top 10% of the class for the final year of the whole course, compared against the number of women passing the course, and again
- the comparable ratio for men.

The first measure, of passing rates at the beginning of the courses focusses on the central concerns of this study in two ways: it has elements of early drop out figures and of achievement. This is because there is inconsistency between the various institutions on policies for discontinuation with or without penalty. So, for example, in some institutions, it is in the student’s interest to formally discontinue from courses by the 30th April and in others it is not. Accordingly, some students who have actually dropped out may not be detected from official April 30th figures; they are detected by their absence from the
group that passes the first units. This means that the pass rates for first units indicates a combination of achievement and early dropout. Indeed, some institutions reported essentially the same enrolment figures for the very beginning of the course and for the 30th April.

Response rate

The response rates for the impressionistic or opinion questions ranges from 90% to 100% and for the participation rates, the response rates vary from about 60% to 80% of courses. At the outset, we appreciated that the latter, numerical data would be difficult to obtain and we are quite satisfied with the response rates. We considered those departments responding to be fairly representative, as the following table indicates.

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<thead>
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<th>Table 1: Item Response Rates</th>
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<td>Description of data</td>
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<td>Data for both men and women passing the course in 1984</td>
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<td>Note large universities</td>
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<td>Data for both men and women enrolled in first units at 30th April, 1984</td>
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<td>Data for both men and women in the top 10% of first units in 1985</td>
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Small scale interviews

A smaller number of institutions were studied in greater depth to gain a qualitative understanding of the factors that might contribute to the quantitative data that comes from the large scale survey. In view of the scope of this study, this part of the work had to be
limited: this aspect of the project aimed to identify major issues that might be relevant to both the interpretation of the survey data and in the formulation of future directions of research. In particular, we sought to identify major issues by interviewing students and staff at a selection of the institutions covered by the larger scale quantitative survey.

**Student interviews**

The motivation for this part of the study was to get an appreciation of the particular problems that computing students identify. We arranged a series of interviews with women and men who were students at eight of the institutions from the large scale study. We interviewed both women and men so that we might compare the experiences and problems reported women against those from men.

The institutions were selected to give a range of course types: they included small and large departments, CAE’s and universities, Computer Science and more commercially oriented courses and city departments as well as one institution from a small town.

The interviews involved a total of 88 final year students, survivors of the system. By this point in their studies, the students might be able to see their problems in some perspective. The interviews were conducted using the Nominal Group Technique (Hegarty 1977) where they were first asked to think individually about the problems that they had experienced. Then followed a group discussion to develop a list of problems for the whole group and finally, each student made an individual record of the five most significant problems that they had encountered. At that point, they were free to include problems that had been identified by the group or any others that they wished to offer privately (but had not seen fit to bring out in the group discussion.) In addition, the interviewer invited women students to stay behind to discuss the matters raised in a smaller group.

These were analysed for each institution with the problems broken down by the sex of the student reporting them. The individually recorded problems were analysed and the interview data that had been drawn from the comments of women who chose to stay behind.

The analysis was done for each department separately to form a component of the case study for that department. As a final stage, these had to be integrated in several ways: with the other student interview case studies; with the staff interview data for that department and, of course with all the other aspects of the study.

**Staff interviews**

The staff interviews investigated whether the staff perceive that women experience any special problems. The staff interviewed were selected as being

- responsible for teaching policy in the first year of the computing courses or
- having considerable contact with first year students.

Often, one staff member had both of these attributes. The interviews sought to document staff perceptions of difficulties that particularly affect women and what they are doing or would like to do to remedy the situation.
The interviews were very loosely structured so that staff could present their own views without being directed or led. The interviewer asked a sequence of broad questions and recorded the responses, checking the accuracy of the recording as the interview proceeded.

The interviewer asked the staff member to comment on:

- advantages for women in studying computing;
- disadvantages for women in studying computing;
- differences between women and men in studying computing; (and the interviewer classed these as: on entry, in first year or by final year)
- any of the differences that are advantages;
- any that are disadvantages or problems for women;
- approaches to resolving problems for women in studying computing;
- teaching initiatives and
- issues or problems likely to emerge in the future.

The analysis of the interview data summarised the issues reported at each stage of the interview. The sex of the staff members reporting each issue was also analysed. These were collected and compared across institutions.

**Intervention strategies**

The final component of the work was to investigate two approaches to intervention. These were applied at the University of Sydney, where it has been established that women are over-represented in the group of students who discontinue from computing in the very first months of the first year and where women are under-represented at the top of the class. Two approaches were evaluated:

- an orientation program that taught the students pre-programming skills;
- a counselling programme.

At the outset, we felt that participation rates for women might be increased by action at the very beginning of the course. We knew that this was when women’s participation rates dropped relative to men’s in the course at Sydney University and so, we evaluated two approaches to the problem. The first was run before the beginning of the course and was intended to serve as a form of orientation and the second was attempted several times in the first half of the first year of the course.

**Analysis of handbook materials**

This component of the study had two major motivations:

- to help define the image of computing courses as they portray themselves in these documents and
• to identify any aspects of these documents that might make the courses appear more or less attractive to women.

The following aspects were analysed:

• statement of course objects;
• pre-requisites and co-requisites;
• mention of appropriate study skills;
• emphasis of problem solving;
• emphasis of high-tech, new world image of computing;
• mention of the social implications and vast range of applications of computing, not only in highly technical areas, but also in many applications that involve dealing with people;
• presentation of computing as part of a general education;
• comments on the difficulty of the course;
• use of jargon or sexist language.

In establishing formal contact with each department that was part of the large scale survey, we requested handbooks and related information that is provided for students entering the course. The analysis covered a group of 28 departments that are characteristic of the range of institutions.
APPENDIX V - QUESTIONNAIRE WITH SUMMARY DATA

1. Are the following used to select students for this course? Tick Yes or No as appropriate

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall HSC (or equiv) aggregate</td>
<td>37</td>
<td>1</td>
</tr>
<tr>
<td>High school mathematics result</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>High school English result</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Institution/School/Faculty/Department quota</td>
<td>32</td>
<td>5</td>
</tr>
<tr>
<td>Other please specify</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

2. Indicate the emphasis the course gives to each of the following. Circle 1 for heavy emphasis, 2 for some emphasis, 3 for little emphasis and 4 for no emphasis

<table>
<thead>
<tr>
<th></th>
<th>Heavy emphasis</th>
<th>No emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer science</td>
<td>1(21) 2(8) 3(10) 4(1)</td>
<td></td>
</tr>
<tr>
<td>Data processing</td>
<td>1(12) 2(16) 3(10) 4(3)</td>
<td></td>
</tr>
<tr>
<td>Information Systems</td>
<td>1(16) 2(15) 3(9) 4(1)</td>
<td></td>
</tr>
<tr>
<td>Other please specify</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

3. Please indicate how your department rates the importance of high school mathematics for students’ ability to cope with the following aspects of your course. Circle 1 for very important, 2 of some importance, 3 of little importance and 4 irrelevant

<table>
<thead>
<tr>
<th></th>
<th>Very Important</th>
<th>Irrelevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving skills</td>
<td>1(15) 2(17) 3(5) 4(1)</td>
<td></td>
</tr>
<tr>
<td>Mathematical sophistication</td>
<td>1(8) 2(10) 3(14) 4(6)</td>
<td></td>
</tr>
<tr>
<td>Mathematical proof skills</td>
<td>1(5) 2(14) 3(14) 4(4)</td>
<td></td>
</tr>
<tr>
<td>Material covered</td>
<td>1(7) 2(7) 3(15) 4(4)</td>
<td></td>
</tr>
</tbody>
</table>

4. How many students passed the whole course (i.e. successfully completed the final year) in 1984?

<table>
<thead>
<tr>
<th></th>
<th>Full-time enrolments</th>
<th>Part-time enrolments</th>
<th>All</th>
</tr>
</thead>
</table>

5. Of the students who completed the course in 1984, please indicate the numbers in the top 10%.
First Year of Course

6. Please indicate the emphasis given to the development of the following skills in the first year of the course. Circle 1 for heavy emphasis, 2 for some emphasis, 3 for little emphasis, 4 for no emphasis

<table>
<thead>
<tr>
<th>spielen</th>
<th>Heavey emphasis</th>
<th>No emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery of operating system and text editor</td>
<td>1(11) 2(20) 3(6) 4(3)</td>
<td></td>
</tr>
<tr>
<td>Problem solving skills</td>
<td>1(29) 2(8) 3(4) 4(0)</td>
<td></td>
</tr>
<tr>
<td>Program coding skills</td>
<td>1(25) 2(12) 3(2) 4(1)</td>
<td></td>
</tr>
<tr>
<td>Mathematical proof skills</td>
<td>1(4) 2(10) 3(13) 4(13)</td>
<td></td>
</tr>
<tr>
<td>Writing skills (English)</td>
<td>1(5) 2(15) 3(13) 4(8)</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

7. Please indicate if any of the following measures is available to assist students encountering difficulties in the first year of the course. Tick as many as relevant.

<table>
<thead>
<tr>
<th>.vx</th>
<th>Within your department</th>
<th>Elsewhere in institution</th>
<th>Not available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remedial computing assistance</td>
<td>19</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Duty tutor/programmer/consultant service</td>
<td>32</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Maths bridging courses</td>
<td>9</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Remedial Maths assistance</td>
<td>6</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>Remedial English assistance</td>
<td>2</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The First Unit(s)

8. Please list the first computing unit(s) students may take in the course. Please include all unit(s), be they compulsory or not, that are taught by your department and that are offered in the first term/semester. A unit will typically have duration of no more than a year and should have assessment associated with it. (See page 1 for the definition of a unit.)

Comments:
Name of department/school:
Name of contact:
Name of course:

9. Please give the name of the unit covered in this copy of the form.

10. Is it compulsory?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>4</td>
</tr>
</tbody>
</table>

*If yes, please skip to question 12.*

11. Does taking this unit restrict a student’s choice of subsequent units?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>17</td>
</tr>
</tbody>
</table>

*If yes, please explain.*

12. Please indicate how much time each student was allocated per week and the associated class size for the following forms of teaching in this unit in 1985.

<table>
<thead>
<tr>
<th></th>
<th>Contact hours per week</th>
<th>Class size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>2.2/61</td>
<td>151.7/56</td>
</tr>
<tr>
<td>Tutorials</td>
<td>1.0/61</td>
<td>20.8/60</td>
</tr>
<tr>
<td>Laboratory or other practical class</td>
<td>1.1/58</td>
<td>10.3/57</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. Please indicate the number of people who were involved in giving lectures, taking tutorials and teaching other practical work in this unit on a regular basis in 1985.

*Include all casual, part-time and permanent staff.*
<table>
<thead>
<tr>
<th>Tutors - full-time or fractional</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.7/63</td>
<td>1.6/63</td>
</tr>
<tr>
<td>Tutors - casual</td>
<td>0.8/63</td>
<td>3.1/63</td>
</tr>
<tr>
<td>Lecturers</td>
<td>0.5/63</td>
<td>1.5/63</td>
</tr>
<tr>
<td>Senior Lecturers</td>
<td>0.0/63</td>
<td>0.5/63</td>
</tr>
<tr>
<td>&gt;Senior Lecturers</td>
<td>0.0/63</td>
<td>0.3/63</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. How many students initially enrolled in this \textbf{unit} in the years listed?
\textit{For a definition of unit, see page 1.}

<table>
<thead>
<tr>
<th>Year</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>56.9/37</td>
<td>147.1/37</td>
</tr>
<tr>
<td>1985</td>
<td>56.0/43</td>
<td>141.6/43</td>
</tr>
</tbody>
</table>

15. Please give the numbers of students who were enrolled in this \textbf{unit} at the end of April for the years listed.
\textit{April 30th is the date for which institutions report enrolments to the CTEC.}

<table>
<thead>
<tr>
<th>Year</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>52.0/39</td>
<td>121.7/39</td>
</tr>
<tr>
<td>1985</td>
<td>48.0/49</td>
<td>123.1/49</td>
</tr>
</tbody>
</table>

16. How many students passed the \textbf{unit}?
\textit{If 1985 figures are not available, please omit them.}

<table>
<thead>
<tr>
<th>Year</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>34.2/41</td>
<td>92.2/42</td>
</tr>
<tr>
<td>1985</td>
<td>35.8/35</td>
<td>106.9/36</td>
</tr>
</tbody>
</table>

Comments:

17. Of the students who passed this \textbf{unit}, please show the numbers of women and men in the top 10%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>3.9/38</td>
<td>11.6/38</td>
</tr>
<tr>
<td>1985</td>
<td>4.6/35</td>
<td>14.1/38</td>
</tr>
</tbody>
</table>

18. What difficulties, if any, do you believe women in particular experience in the overall \textbf{course}?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

58
19. What difficulties, if any, do you believe that women in particular experience in the first year of the course?
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

20. Do you have reason to believe that women tend to do better in some units than they do in others?
*Tick the appropriate box.*

Yes  No

If yes, please comment
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

21. Do you have reason to believe that women tend to do badly in some units?
*Tick the appropriate box.*

Yes  No

If yes, please comment
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

59
22. Any other comments.

Thank you for your time and effort.

Penny Collings
Judy Kay
Jackie Lublin
Gretchen Poiner
Mike Prosser

APPENDIX VI - LIST OF WORKING PAPERS

• Large scale questionnaire.
• Student interviews.
• Staff interviews.
• Handbook analysis.
• Canberra CAE case study.
Investigation of the Status of Women at Early Stages of Professionally Accredited Tertiary Computer Science and Data Processing Programmes†

J. Kay, University of Sydney
P. Collings, Canberra College of Advanced Education
J. Lublin, University of Sydney
G. Poiner, University of Sydney
M. Prosser, University of Sydney

and

R. Bishop,
K. Watson

† This study was funded by a grant from the Commonwealth Tertiary Education Commission, Evaluation and Investigation Programme. The work was also supported by the Department of Computer Science, the Centre for Teaching and Learning and the Vice-Chancellor’s Office at the University of Sydney.
ABSTRACT

The principal concerns of this study have been to investigate women’s representation in professionally accredited computing courses. We consider the degree to which women are drawn to these computing courses in the first instance, whether those women who do enrol in them continue to be attracted to the discipline and, how well women achieve academically. We have sought to identify factors contributing to explanation of the patterns of participation which have emerged and to identify forms of intervention approaches that would assist women in computing courses. There were three major objectives in the study.

1. To gain a quantitative picture of the representation of women in Australian computing courses that are professionally accredited. In particular, this study aimed to establish the number of women starting such courses, the number finishing and the number awarded highest grades in the courses.

2. To identify issues that students and staff perceive as relevant for the representation and success of women in such courses.

3. To evaluate some approaches to providing support and assistance to women at the beginning of their computing studies.

This study focused on courses offered in Australian CAEs and universities which have a major role as vocational training for programmers, analysts and other professionals with a high degree of computing skill. We surveyed all departments offering such courses. In addition to statistical data on women’s representation at the early stages of the courses, the questionnaire collected other quantitative and qualitative data to provide a context for the interpretation of the statistical data. A smaller number of institutions was selected for student and staff interviews. A component of the study involved analysis of handbooks and other materials that are made available to students entering the courses. Another phase of the project investigated intervention strategies.

Our major findings on women’s representation in the courses in 1984 and 1985 are:

- women constituted about a quarter to a third of the enrolments in most courses;
- women outnumbered men three-to-two among those who discontinued by the 30 April in the first year of the course;
- women were slightly less likely than men to pass in the first units;
- there were slightly fewer women at the top of the class in the first units.

In addition, we found that in the graduating class of 1985,

- there were proportionately more women than men at the top of the class.

Overall, our statistical findings suggest that there are particular problems for women in the very early stages of the courses and that some aspects of teaching method, curriculum and course emphasis and orientation relate to better outcomes for women in these early stages of the course.

Our investigations suggested that explanations for these findings could usefully be explored at three levels:

- in terms of the discipline itself;
- in the role played by the institutions in the way that they structured and presented the courses;
- in terms of the perceptions, attitudes and interactions of individual students and staff.

Probing these three dimensions, we identified a series of variables which serve to discourage women from and in computing courses.
1. At the disciplinary level, we have observed the commonly projected image of computing to be
   • heavily technology-centred and
   • reliant upon mathematics,
classes of knowledge and orientations that have been traditionally and formally less accessible to women and ones whose importance to the discipline is frequently overrated. By contrast, we have observed that other aspects are commonly underrated, including
   • the importance of communication
   • interpersonal skills,
areas in which women traditionally have strength.

2. At the institutional level, the major issues that were identified are:
   • effects of assumptions of students’ previous computing knowledge and experience;
   • effects of women’s typically weaker mathematics background;
   • the coverage and sequence of material within the courses;
   • effects of heavy workload and scarce resources.

3. At the level of the individual, we have identified stereotypes and the attitudes and behaviours that follow from them. In particular, we have examined these in terms of:
   • interactions between students and staff;
   • interactions between students;
   • technology centred attitudes to the machine.
Our central findings are:
   • Women’s participation seems to be largely determined either before their entry to tertiary institutions or in the first few months in the courses.
   • Intervention would seem more likely to succeed if it is structured and closely related to the course of study and if it occurs either immediately before or very early in the first year.

We also report two approaches to intervention that we investigated: an orientation programme and a counselling programme. Both addressed the problems of women at the early stages of the first year of the course.
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