An exploratory study of the representation and performance of females in Information Technology at Murdoch University

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Abstract

This paper presents some preliminary statistics about male and female entry, persistence and success rates in Information Technology courses at Murdoch University. The figures show that, like other countries, females make up only a small percentage of the overall student body in these courses. Further, they show that females have the same persistence and success rates as males, and that in some cases females perform better than males. Finally, the paper discusses further research that could be considered in this area.

Keywords: Gender, Information Technology, female performance, female representation, Australia

1. INTRODUCTION

This paper is a preliminary study into the representation and performance of females in Information Technology courses at Murdoch University in Western Australia. There has been growing concern in many countries about the under representation of females in Information Technology (Pearl, 1995) (Brown et. al., 1997) (Warne, 2000). Observation within the School of IT for many years has suggested that females are under represented in most, if not all units in IT. This is especially evident in final year project units when there is often at most one female in each team of five students. This study aimed to quantify the level of representation of females in the IT courses at Murdoch University, and also to discover if females performed the same as males in the various Information Technology units.

Information Technology at Murdoch University

Murdoch University has offered a Bachelor of Science in Computer Science since 1985 and a Bachelor of Science in Information Systems since 1991. Graduate Diplomas in Computer Studies (since 1985) and Information Systems (since 1996) are also offered. The Computer Science degree covers the more technical and programming-oriented subjects, while Information Systems has a more human and organizational focus. Both courses cover the basics of systems development, databases, and data communications. Unusually in Western Australia, both Computer Science and Information Systems are located within the same school, the School of Information Technology (IT). Restructuring at University level in 1997 saw IT move from a science-based faculty to its present location in the Division of Business, Information Technology and Law.

The undergraduate degrees take 3 years fulltime to complete and the graduate diplomas 1 year. Students are also able to complete part-time over a longer period, and in the case of Computer Science, to complete the entire degree in external (distance) mode. Murdoch University offers students a good deal of flexibility in terms of being able to transfer between courses, and combine courses to complete a 'double major', and this is especially true of the Computer Science and Information Systems courses, which have several units in common.

Several of the units offered by IT are service units that are also taken by students enrolled in other courses, notably Introduction to Information Technology and Commercial Computing (both required in the Bachelor

of Commerce), Introduction to Computer Science (required by Computational Physics), and since 1999 Introduction to Multimedia and the Internet (required by the Bachelor of Commerce and the Bachelor of Multimedia).

Representation of females in Information Technology courses

Studies overseas have found that females are significantly under represented in all Science and Engineering courses, including Computer Science. For example Klawe and Leveson (Klawe and Leveson, 1995) report that in the USA female participation in Computer Science courses was 19% in 1975 and rose to 35% in 1982, but that in the nineties has fallen to approximately the same percentage as the seventies. In Germany, Behnke and Oechtering (Behnke and Oechtering, 1995) report that in West Germany 13% of Computer Science students were women, this rose to a high of 19% in 1978, but then fell to 9.5% and appears to be still declining. They further report that since the reunification of East and West Germany there has been a considerable decline in the participation of women in IT. In East Germany in 1985, 58% of IT students were women, by 1993 only 11% were women. Durndell, and Thomson (Durndell, and Thomson 1997) report that in the UK, 11% of admissions to computing courses were female in 1987, and that this had grown to 18% by 1995. Cole et. al. (Cole et. al, 1994) report that in 1994 in Scotland females represented less than 25% of students taking Computer Science studies.

These findings are reflected in similar studies in Australia. Fitzsimmons (Fitzsimmons, 2000) reports an average of 20% females in university courses. The study presented here was carried out to determine the representation and performance of females compared to males in IT at Murdoch University. This preliminary study is to form the basis for further research with the ultimate aim being to attract more females into IT.

Performance of females in Information Technology

Studies overseas have shown that in general females perform at least as well as males in IT courses. For example, Klawe and Leveson (Klawe and Leveson, 1995) report that females in IT perform as well as their male counterparts and Cole et. al (Cole et. al, 1994) report that females perform better than males.

In Australia, a study based on Higher School Certificate grades of final year high school students in 1992 in New South Wales found that there was no significant difference in performance between the females and males who completed Computer Science. (MacCann, Robert, 1995) The same study found that although participation by females in the more advanced mathematics courses was lower, their performance in these courses was higher than males.

2. RESEARCH QUESTION

The study aimed to answer two main questions:

1. What is the representation of females compared to males in Information Technology courses at Murdoch University?
2. Do females perform any differently from males, in terms of grades achieved, in Information Technology units?

Within these main questions several sub-questions were identified:

Representation:

1.1 Does the representation of females show any trends over time?
1.2 Is there any difference in female representation between the different IT courses?
1.3 Is there any difference in representation of females between Australian and International students?
1.4 Is there any evidence that female students are more likely than males to 'drop out' before completing their qualification?

Performance:

2.1 Do females perform differently in any specific units?
2.2 Do females perform differently in introductory compared to advanced IT units?
2.3 Do females perform differently in Information Systems units compared with Computer Science units?
2.4 Do females perform differently in service units compared to IT-only units?

3. RESEARCH METHOD

Two main sources of data were used in this study. Statistics about course enrolments were taken from the University summary statistics pages available on the Murdoch University web site (www.murdoch.edu.au). These pages are summarized from the data recorded about individual students in the student records system and provide statistical information on the student body broken down by course, gender, enrolment status, fee status, and other variables. Figures are available from 1989 onwards. These statistics were used to determine the representation of female students in Information Technology courses, compared across various categories.

Information about grades was extracted directly from the student records system. Grade information was collected for all IT units offered from 1997-99, 30 units in total. For each unit, the total number of females and males in each grade was recorded. The grades used at Murdoch are High Distinction (80%+), Distinction (70-79%), Credit (60-69%), Pass (50-59%) and Fail (below 50%). Marks are used to calculate grades but are not recorded in the student records system.

The data was analysed using chi-squared tests for independence to determine whether the observed distribution of grades for females and males was significantly different from that expected from the normal distribution. The alpha statistic or probability of a significant deviation from the expected distribution was calculated using the CHITEST function in Microsoft Excel™.

4. RESULTS

Representation of females in Information Technology
Table 1 shows the total number of students enrolled in each of the IT courses at the start of 2000 and the percentage of this total who are female. The proportion of females is low in the two undergraduate degrees and the Graduate Diploma in Computer Studies, but is nearly 50% in the Graduate Diploma in Information Systems.

Qualification	Total enrolment	% Female
BSc Computer Science	337	20%
BSc Information Systems	189	24%
Graduate Diploma in Computer Studies	47	23%
Graduate Diploma in Information Systems	19	47%

Table 1. Number of students enrolled in IT courses in 2000.

These figures compare with a Divisional percentage in 2000 of approximately 51% female (across all qualifications) and a university-wide percentage across all qualifications of 59% female.

Trends over time
Figure 1 shows the percentage of female students 'commencing' each IT course (i.e. either enrolling in the course on their initial entry to Murdoch or subsequently transferring into it) from 1989-2000. Commencing data provides a good indication of student choice of course from year to year.

The proportion of female students commencing in IT courses varied from a low of 10% (in the BSc Computer Science in 1995) to a high of 50% in the Graduate Diploma in Information Systems in 1996. Although representation varies from year to year there is some indication in Figure 1 of a decline in the proportion of females from the early to the mid-1990s, and a slight increase thereafter.

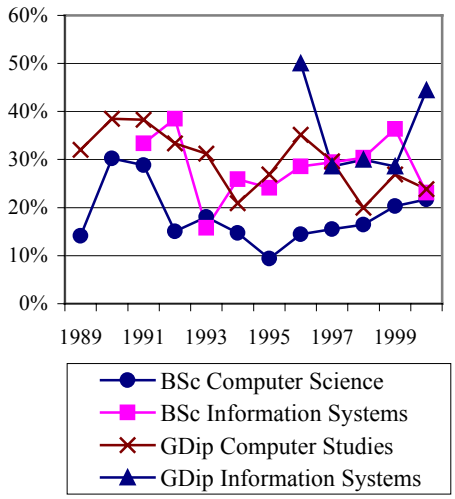

Figure 1. Female students as percentage of students commencing in IT courses, 1989-2000.

Over the period shown in Figure 1 the total number of students enrolling in the BSc Computer Science ranged from 85-142, in the BSc Information Systems from 9-66, in the Graduate Diploma in Computer Studies from 20-47, and in the Graduate Diploma in Information Systems from 7-14. However, no conclusions can be drawn from these figures as to trends in demand for any of the courses, as each course is subject to varying university-imposed quota each year.

Computer Science and Information Systems courses
At the undergraduate level, proportionately more female students chose to do Information Systems than Computer Science over the period 1989-2000, and more males chose Computer Science rather than Information Systems ($p=0.00004$). However, there was no such difference at the graduate diploma level, with females and males equally likely to choose either course ($p=0.36530$).

Australian and International students
The University statistics pages define 'Australian' as Australian citizen, permanent resident, or New Zealand citizen. 'International' students are those not falling into one of these categories. Many international students in IT at Murdoch come from south-east Asia, some through articulation courses that provide direct entry into second year. International students made up approximately 17% of the total student body in IT in 2000. This compares with a Division average of 32% (due mainly to a very high proportion of international students in Commerce courses) and a university figure of 16%.

Qualification	Aust. students	Int. students	% Int.
BSc Computer Science	298	39	14%
BSc Information Systems	151	38	20%
GDip Computer Studies	46	1	2%
GDip Information Systems	13	6	32%

Table 2. Proportion of Australian and International students in each IT course in 2000.

A comparison was made of commencing data for female and male Australian and international students in both IT undergraduate courses over the period 1989-2000. The chi-squared test showed no association between gender and nationality ($p=0.15134$), indicating no difference in proportion of female students between Australian and international students.

The same data was analysed separately for the Computer Science and Information Systems undergraduate courses. This showed a highly significant difference between the two courses for Australian students, with male Australian students much more likely to choose Computer Science than Information Systems, and female Australian students much more likely to choose Information Systems ($p=0.00001$). However, the distribution of male and female international students between Computer Science and Information Systems was in almost exactly the expected proportions ($p=0.81313$), indicating no preference between female and male international students for Computer Science or Information Systems.

Completions

To investigate whether females were more (or less) likely to drop out of their course, completions of qualifications were compared for female and male students in Information Technology. Completion data was available for the BSc Computer Science from 1989-1998 and for Information Systems from 1994-1998. Average female and male completion rates over these periods (as a percentage of the total number of students enrolled in the course) were almost identical, in both Computer Science and Information Systems courses (Table 3).

	Completions			
Qualific.	Female	Male	Female as % of enrolled students	Male as % of enrolled students
BSc CS	54	243	12.7%	12.3%
BSc IS	23	77	24.5%	25.0%

Table 3. Female and male completions in the BSc Computer Science (1989-98) and BSc Information Systems (1994-98).

The completion rate in Computer Science was about half that of Information Systems. This may in part reflect the fact that the Computer Science degree can be completed wholly in distance mode, and many students choose to complete it part time over several years in this mode while continuing to work part or full time.

Performance in units

Individual units: The distribution of grades for female and male students was tested using the chi-squared test for independence for each of the 30 units for the combined data of 1997-99. The results are shown in Table 4 along with the total enrolments in each unit. In most units, the observed grade distributions for females and males did not differ significantly from the expected distributions. Significant variations were found in only six units. These were Introduction to Information Technology (females higher than expected in HD, D, C categories and lower in P, N); Fundamentals of Computer Systems (females higher than expected in HD), Commercial Computing (females higher than expected in D, lower in Fail), Data Structures and Abstractions (females higher than expected in D and C, lower in Fail), Intelligent Systems (females higher than expected in D, lower in Fail), and Systems Design (females higher than expected in HD). Where there were significant differences therefore, they were all on the side of better grades achieved by females.

Service units: As mentioned, the data for the two large service units, Introduction to Information Technology and Commercial Computing, showed better than expected female performance over the three years combined. Their data was also analysed for the three years separately to see if the trend towards better grades for females was consistent.

UNIT Note: [C] indicates unit required for CS only, [I] IS only	No. of enrolments 1997-99	Probability level for association, p
FIRST YEAR UNITS		
Introduction to Computer Science	773	0.77838
Principles of Computer Science[C]	447	0.83497
Introduction to Information Technology[I]	2718	0.04185 *
Fundamentals of Computer Systems[C]	157	0.02438 *
Principles of Information Systems[I]	395	0.15712
Introduction to Multimedia and the Internet[I]	439	0.83399
SECOND YEAR UNITS		
Commercial Computing[I]	1569	0.02952 *
Data Structures and Abstractions[C]	291	0.00004 ***
Commercial Application Development[I]	80	0.07165
Internet Computing	165	0.98183
Computer Systems[C]	184	0.64856
Computer Graphics and Image Processing	165	0.27752
Databases	437	0.08582
Intelligent Systems	87	0.01525 *
Systems Design[I]	260	0.00210 **
Data Communications	429	0.29533
Systems Analysis	479	0.07334
THIRD YEAR UNITS		
Software Architectures[C]	198	0.40597
Compiler Design[C]	69	0.33253
Unix and Network Programming[C]	120	0.30622
Software Engineering Project[C]	147	0.42030
Human-Computer Interaction[I]	163	0.44599
Information Systems Management[I]	157	0.09974
Information Systems Specification[I]	149	0.37276
Information Systems Project[I]	103	0.54749
Organisational Informatics[I]	53	0.21308
Electronic Commerce and Virtual Organisations[I]	44	0.81435
Multimedia Databases[I]	38	0.37577
Software Engineering 1[C]	89	0.72116
Software Engineering 2[C]	82	0.23877

Table 4. Grade analysis for all units, 1997-99. Chi-squared test for independence on grade distribution (HD, D, C, P, Fail) among females and males. *p<0.05, **p<0.01, ***p<0.001, df=4.

In Introduction to Information Technology, a significant difference was found only in 1999, with females gaining more than expected HD, D, and C, and lower than expected P and Fail (p=0.01870). In 1998 (p=0.72574) and 1997 (p=0.20002) there was no difference. In Commercial Computing there was a significant difference in 1997, with females gaining more than expected D and lower than expected P grades (p=0.01466), but there was no difference in 1998 (p=0.18443) or 1999 (p=0.23642). It does not appear, therefore, that there was any consistent trend towards higher grades for females in these units.

Computer Science/ Information Systems units: Grade distribution for females and males was compared for the third year units specific to Computer Science (6 units; see Table 4) and Information Systems (7 units). Data for the three years was combined for Computer Science and Information Systems separately. The chi-squared tests showed no significant difference in grade distribution between female and male in either Computer Science (p=0.82492) or Information Systems (p=0.22874). Similar analyses using combined pass grades (HD, D, C and P) showed no differences in pass/fail rates between females and males in either Computer Science (p=0.79849) or Information Systems (p=0.08554).

Introductory and advanced units: The three years of unit data was grouped by first, second and third year units and grade distribution compared for females and males. This analysis might be expected to reveal any difference in female performance related to 'difficulty' level of the units. There were 6 first year units with a total of 4929 enrolments (see Table 4), 11 second year (3452 enrolments) and 14 third year (1391 enrolments).

An analysis of combined pass/fail data for each set of units showed that significantly more females than males passed in first year units (p= 0.00001) and second year units (p=0.00005). The same trend was present and marginally significant in third year units (p=0.06255). A comparison of all grades for the same data showed a significant difference for first and second year units, with females gaining more than expected HD, D and C grades (first year: p=0.00001; second year: p=0.00000), but there was no significant difference in grade distribution between females and males in third year units (p=0.17401). This trend may partly reflect the better performance by females in the large service units, discussed earlier.

All IT-only units: Finally, the distribution of grades for female and male students was compared across all IT-only units (i.e. excluding the service units Introduction to Computer Science, Introduction to Information Technology, Introduction to Multimedia and the Internet, and Commercial Computing, where IT students make up a relatively small proportion of the total) for 1997, 1998, and 1999. In each year there was a trend towards greater than expected high grades for females and fewer than expected Fail grades. In 1999, females had more than expected HD and fewer than expected Fail, with the other grades the same as expected (marginally significant at p=0.05071). In 1998 females had more than expected HD and D grades, with fewer than expected C, P and Fail (p=0.00000); and in 1997 females had greater than expected D and C grades with fewer than expected P and Fail (p=0.00912).

5. DISCUSSION

This study confirmed the belief that females are under represented in Information Technology courses at Murdoch University. This under representation has been evident for at least ten years and there is no indication that this is changing. Further, it showed that females are more likely to enrol in the Information Systems course than the Computer Science course. The Information Systems course deals with all aspects of information, including recording, storage, communication and application as it relates to many different human activities, and hence is much more application oriented. Various researchers (Kerner and Vargas, 1994) (Durndell, 1990) have reported that females (more than males) need to see a purpose to their studies and place great importance on the social aspects of the subjects they are studying. This could explain females' preference for Information Systems. Computer Science deals, in general, with the more technical side of IT and females' reluctance to take Computer Science could be explained by the fact that male and females consider IT to be the domain of the male, geek stereotype. Fitzsimmons (Fitzsimmons, 2000) recounts that females make up almost 50% of students in Australian universities in specialist courses such as computing/law or computing/international studies. These courses would appear to suit women more as they have a specific application for the computing studies they undertake.

Although international students have the same percentage of females overall as their Australian counterparts, the same preference by females for Information Systems was not evident. The authors believe that the factors affecting the choices made by Australian female undergraduate students needs to be further investigated. Since this preference for Information Systems is not evident in international students, it begs the question of why it is evident in Australian female students.

This study also found that female students complete their courses at about the same rate as males. The literature presents differing results on the issue of the persistence of females in IT courses. Some studies (Galpin and Sanders, 1993) have found similar results to this study, but a recent New Zealand study found that females dropped out of Computer Science courses more

frequently than males (Brown et. al., 1997). Cohoon (Cohoon, 1999) reports the same attrition of female students from Computer Science courses at the University of Virginia. At Murdoch University the students choosing IT are persevering with the course. The problem of the shrinking pipeline as we consider female participation in post graduate courses and academia was beyond the scope of this study, but is seen as a natural extension.

There is no evidence that female students in Information Technology performed any worse than males. In fact in all cases where differences from the expected distribution was found, females performed better, in terms of grades, than males. This is consistent with other studies (Cole et. al, 1994) into this area.

Other studies (Klawe and Leveson, 1995) have highlighted the fall in self confidence in women IT students, but this was not shown here. Performance of females was at least equal to males in advanced units and completion rates were almost identical.

6. FURTHER STUDY

Students' perception of IT needs to be investigated and this may need to be done with High School students because these perceptions are formed long before they enter University (Durndell, 1997). Of particular interest is the different perceptions, by females, of Computer Science and Information Systems.

Investigating why Australian males are more likely to choose Computer Science and Australian females are more likely to choose Information Systems could lead to a better understanding of why there are so few females in Computer Science courses, and also how more can be attracted to these courses.

This analysis has laid the foundation for further study of the issue of females in Information Technology at Murdoch University. The performance data used here was not able to distinguish between student characteristics other than male/female. The authors intend to undertake further analyse of performance data to investigate the importance of factors such as age, qualification level and mode of study (Internal/External, Full-time/Part-time).

This study has confirmed that females are more than competent at IT. History shows that women have been instrumental in creating many of the basic constructs of IT, including loops, subroutines and the concept of a compiler (Gürer, 1995) and hence highlights the need to encourage more females into this discipline.

7. ACKNOWLEDGMENTS

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