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Diversity in information and communication technologies: The cost of lost opportunities

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Biography

Sue Webb is currently a PhD Candidate at Edith Cowan University. Her PhD research involves investigating the declining participation of women studying and working in the field of Information and Communication Technology. Sue lectures part-time for ECU and PIBT. Her other research interests include information security, systems and database design, and wireless networking technology. In March 2004, Sue was awarded the faculty medal for outstanding achievement in an undergraduate programme offered by the Faculty of Computing, Health & Science. Sue's greatest achievement is her 13 year old daughter Caitlin, who is her ally, friend, companion, and occasional ethics teacher.

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Abstract

The Information and Communication Technology (ICT) industry develops products that are used by many people regardless of gender, age, social status, ethnicity, or religion. Technology has had a significant impact on the way that information is produced, stored and communicated, especially in the fields that have traditionally been heavy producers of information such as libraries and education institutions.

Though all types of people use technology, not all types of people are involved in the design and development of technology. Women represent just twenty percent of Australian ICT professionals. They often receive less pay than their male colleagues and are greatly under-represented in management and executive level positions.

The rate of participation of women in ICT has declined steadily since it peaked in the mid eighties, while at the same time, the participation of women in other previously male-dominated fields such as mathematics and physics has continued to climb. Minority and ethnic groups such as Native Americans, African Americans, Hispanics, and Australian Aboriginals are also under-represented in ICT, both in tertiary studies and in industry.

This under-representation of women and minorities in ICT results in a lack of diversity in the creative teams who design and develop this technology. Apart from the issue of equity or fairness, a lack of diversity means that technology is being produced from a very narrow viewpoint which may affect its quality. There is also a hidden or 'opportunity cost' in technology that is never designed and is not produced because of a lack of diversity in creative teams.

This concept paper will address the potential impacts that a lack of diversity in the teams creating technology might have on the way that libraries operate, and the way that information is produced, stored and communicated.

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Introduction

Information and Communication Technologies (ICTs) are a significant part of the everyday lives of nearly all people living in developed countries and an increasing number of people in developing nations. According to O'Neill and Walker (2001, p. 118), ICT's 'are having a similar impact on society as did the industrial revolution in the 18th century in Europe'.

In accordance with this statement, it has been frequently noted that we are in the middle of an 'information revolution' (Jonscher, 1994; Land, 2001; Wajcman, 1991). A significant difference between the current information revolution and the 18th century's industrial revolution is the timeframe in which these innovations transformed industry. The industrial revolution took more than 200 years to comprehensively reshape traditional patterns of work, whereas the information revolution has substantially achieved this in less than 20 years (Multimedia Victoria, 2001).

Almost all jobs today involve some form of ICT for everyday workplace practices, business management, or communication. As an example of the level to which ICTs have permeated society, the Australian Mobile Telecommunications Association (AMTA, 2005) estimate that there are approximately 16 million mobile phone subscribers in Australia, a nation with just over 20 million people.

Computers have also become a commonplace item in many households. In 2003 in Australia, over 66 percent of households had a home computer (Australian Bureau of Statistics, 2004b, p. 1). This figure has grown steadily from 44 percent in 1998. For the same year, the Internet was available in 53 percent of Australian households, up from 16 percent in 1998 (Australian Bureau of Statistics, 2004a).

Advancements in technology mean that many tasks, which were previously labour intensive or not possible, may now be performed with little or no effort. The ICT industry develops and markets products that are used by nearly all types of people, regardless of gender, age, social status, ethnicity, or religion; however, not all types of people are involved in the design and development of technology.

Given the relative newness of the ICT industry, it should theoretically be gender-neutral (Stanworth, 2000) however the reality of the situation is that it is far from this ideal. In fact the industry has been described as 'predominantly white, middle-class and male-dominated' (Panteli, Stack, Atkinson, & Ramsay, 1999).

The technologies themselves are not inherently masculine; however the contexts in which they are produced and used result in particular values and meanings being attributed to them, as well as to those who use them. In other words, technologies are socially shaped, particularly by gender (Harris & Wilkinson, 2004; Wajcman, 1991). According to Peiris, Gregor and Indigo (2000), this social shaping creates a self-perpetuating cycle, dubbed the 'cycle of imbalance' as shown in Figure 1 below.

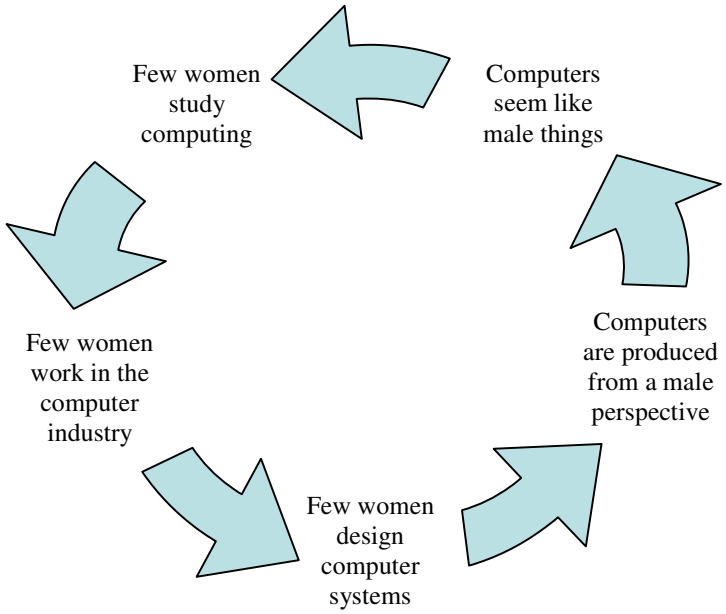

Figure 1 - The Cycle of Imbalance (Peiris et al., 2000, p. 35)

Trauth claims that this social shaping of ICT as 'men's work' places ICT careers outside the domain of women (Trauth, Quesenberry, & Morgan, 2004).

This paper addresses the potential impacts that a lack of diversity in the teams creating technology might have on the way that libraries operate, and the way that information is produced, stored and communicated.

Diversity and ICT

The participation of women in the ICT industry has changed dramatically during the 60 or so years since the industry was born. During that time, prominent women have been recognised as pioneers of the industry however recent figures indicate that they represent between 14 and 32 percent of industry workers. Women are even more greatly under-represented at the higher end of the industry, in management and executive level positions. At a tertiary level, women represent between five and thirty percent of students depending on the country and year under study.

This under-representation has no biological or genetic basis (Fletcher-Flinn & Suddendorf, 1996). That is, ICT work does not require physical strength or any other attributes that are generally lacking in women.

Several studies have shown that women have the same abilities for studying and working with computers as their male counterparts (Fisher, Margolis, & Miller, 1997; Wilson, 2003). How women perceive their abilities though is somewhat different to what their actual abilities are. A self-contradiction exists known as the "we can but I can't" paradox, which refers to the belief that females, as a collective, have abilities that are equal to those of men, however the perceiver believes that their own abilities are less than what they actually

are (Davies, Klawe, Nyhus, & Sullivan, 2000). Wilson proposes that this paradox be reworded as 'we can but I don't want to', stating that women are ambivalent towards technology and opt out of ICT from a lack of interest, rather than a lack of perceived ability (Wilson, 2003).

USA statistics show that in the mid-eighties, the participation of women completing ICT-related tertiary studies peaked at around thirty seven percent and has steadily dropped since. This decline in the participation of women studying and working in ICT is often referred to as the 'shrinking pipeline' phenomenon (Camp, 1997; Gurer & Camp, 2001).

In Australia in 2004, the commencement rate of women taking up ICT tertiary studies was slightly less than 20 percent. This compares to commencement figures for women for the same year enrolling in Natural and Physical science courses of around 54 percent.

Women are not the only group avoiding studying and working in ICT related fields. Minority and ethnic groups such as Native Americans, African Americans, Hispanics, and Australian Aboriginals are also under-represented in both tertiary studies and industry (Moody, Beise, Woszczynski, & Myers, 2003; Robertson, Dyson, Norman, & Buckley, 2002).

This under-representation of women and minorities in ICT results in a lack of diversity in the industry. To achieve true diversity, the mix of workers should include more women, as well as representatives of other cultures, races and religions (Moody et al., 2003; Wardle & Burton, 2002). The scope of this paper however has been restricted to the decline of women in ICT. Other issues, such as age, ethnicity, socio-economic status, and religion are beyond the scope of this paper.

There are several issues surrounding a lack of diversity in ICT. Firstly, there is the issue of equity or fairness as the ICT industry offers many opportunities for wealth and career advancement. According to Kurtz, projections based on Bureau of Labor Statistics data indicate that four of the 10 fastest growing occupations in the United States are in the field of ICT (Kurtz, 2003).

The second issue surrounding a lack of diversity has to do with the quality of the technologies that are being produced. Having a diverse range of individuals in the IT professions provides a richer mix of talents and ideas which can in turn enrich the quality and diversity of design solutions (Sumner & Niederman, 2004).

Without greater diversity, technology is at risk from being designed and developed from a very narrow viewpoint. This perspective is that of white, middle-class, western males, as these are the people who make up the majority of the ICT workforce, especially in the design and development area (Borg, 2002; Johnson & Miller, 2002; Margolis, Fisher, & Miller, 2000). Male designers and developers are often more focussed on the technology itself rather than on the requirements of users or the commercial viability of their products (Montano, 2002; Woodfield, 2002).

Apart from the issue of the quality of technology that is being produced, there is also a hidden or 'opportunity cost' (Wulf, 2002) in technology that is not

designed and is not produced because of a lack of diversity in creative teams.
These factors all indicate that having diverse creative teams is critical if the ICT industry is to move forward and have a positive impact on society.

Women studying ICT
The percentages of women studying ICT varies throughout the world. It is difficult to make direct comparisons because the statistics available vary greatly from country to country. Several countries have been investigated and the data available reported below.

Australia
Figures published for 2002 by the Australian Federal Government Department of Education, Science and Training (DEST) shows the percentage of females graduating from all tertiary courses in Information Technology (IT) at 26 percent (DEST, 2003). This compares to a female participation rate in the fields classified as Natural and Physical Sciences of over 54 percent for the same period (DEST, 2003).
In comparison, the number of females commencing tertiary level IT courses in 2004 had dropped to 19.5 percent. Female students commencing courses in Natural and Physical Sciences held steady at 54 percent (DEST, 2005). Commencement figures for the 2005 academic year were not available at the time of writing.

United States of America (USA)
In the USA, statistics published by the National Science Foundation (2004) show that the number of women completing bachelor's degrees in Computer Science across North America started at around 10 percent in 1966, then rose to a high of around 37 percent in 1983. This completion rate has steadily declined since. For the 2001/2002 academic year, the percentage of female completions was approximately 27.5 percent.
When compared to other science and engineering fields, this decline in computer science degrees awarded is alarming. In the United States, the participation of women in other previously male-dominated fields, such as mathematics and physics, has continued to climb over the same period of time. For example, in 1966 the number of graduating female Engineers was less than one percent with just 136 out of a total of 35,826 graduates. By 1980, this figure had increased to just over ten percent. In 2001, the figure stood at just over 20 percent - see Figure 2 below (National Science Foundation, 2004).

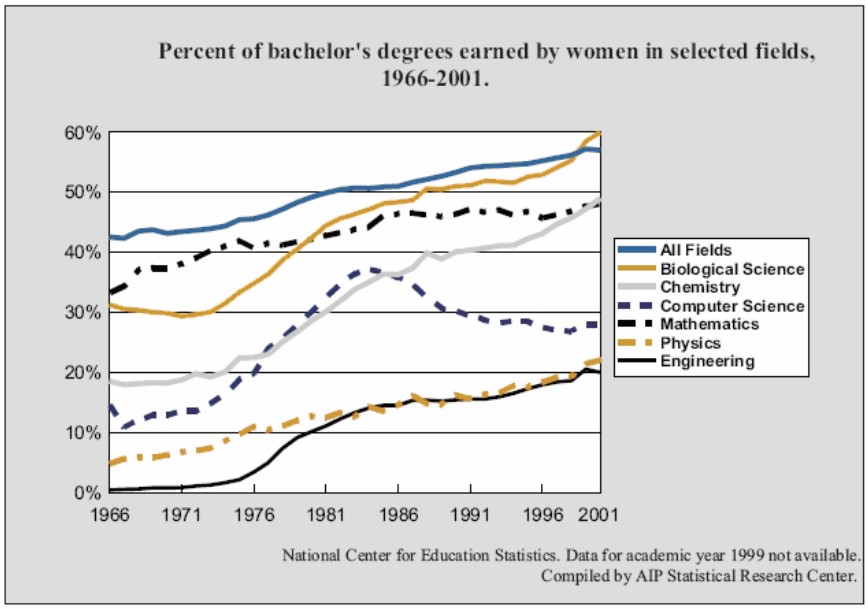

Figure 2 - Percent of bachelors degrees in selected fields earned by women in the United States (Ivie & Ray, 2005, p. 7)

United Kingdom (UK)

In the UK, the participation rate of women studying Computer Science was around 25 percent in 1975, and just 12 percent in 1995 (Suriya & Panteli, 2000, p. 43). It is not clear from the report if these figures represent commencement numbers or completion numbers. Other statistics show the 1995/1996 commencement figures for women studying Computer Science in the UK at 20 percent (Institute for Employment Studies, 2005).

Other Countries

In other countries, the participation rate of females in ICT studies varies greatly. In Canada in 1998, the percentage of women majoring in computer science was approximately 21 percent. The data available for other countries is from varying time periods which makes it difficult to make comparisons, however some comparisons were possible by just looking at the 1999 and 2000 data. In this time period, the rate ranges from 10.5 percent in Germany up to 39.2 percent in Mexico (Galpin, 2002). The lowest reported rate was from Pakistan in 1998 with just 4.99 percent, while the highest rate came from Singapore in 1987, where the rate exceeded 50 percent (Galpin, 2002).

Women working in ICT

Participation rates of women working in ICT are not as readily available as the rates of women studying ICT; however some research has been done to attempt to quantify the levels of female involvement in the ICT industry. The results of this research are shown below, again categorised by geographic region.

Australia

Figures published by the Department of Communications, Information Technology and the Arts, show that in mid 2003, women comprised

approximately 32 percent of all employees of the Australian ICT workforce (DCITA, 2004). Another report shows that 20 percent of ICT professionals were women (Department of Employment and Workplace Relations, 2004). This variance between professional employment levels and overall employment levels indicates that in Australia, a significant proportion of non-professional ICT workers are women.

In 2004, a survey was conducted by the Association of Professional Engineers, Scientists and Managers, Australia which looked at several factors including employment status, level of responsibility, and remuneration. This survey found that of the 969 computer professionals who responded, 16 percent were women, who earned on average five percent less than their male colleagues at the same level of responsibility (APESMA, 2004).

The percentage of females declined as the level of responsibility went up, ranging from 25 percent of respondents at the lowest level of responsibility, down to just 8.5 percent of respondents at the highest level of responsibility (APESMA, 2004). See Figure 3 below for a graphical representation of this decline. See (APESMA, 2005) for a description of the responsibility levels.

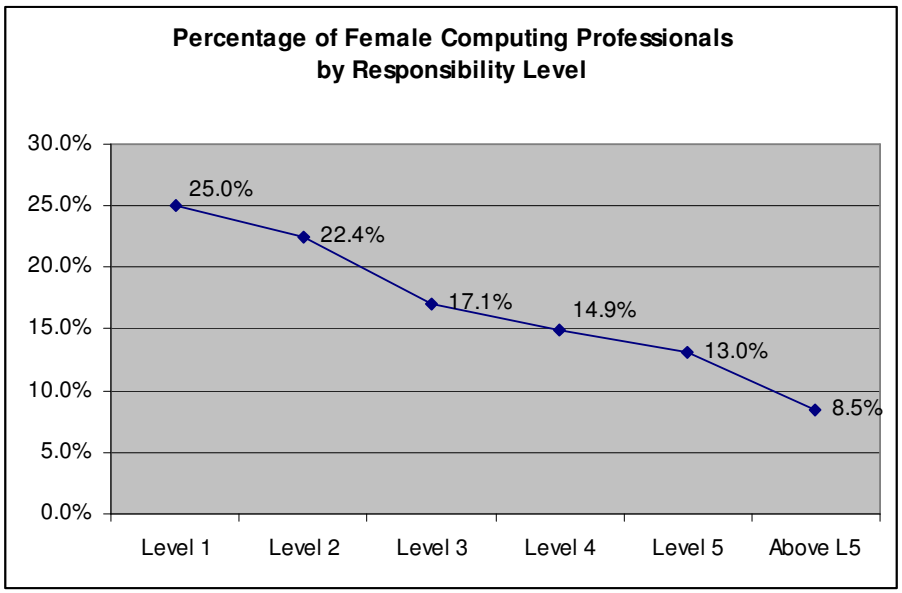

Figure 3 – Percentage of Female Computing Professionals by Responsibility Level (APESMA, 2004)

United States of America (USA)

According to Hill (2005), the participation rate of women working in ICT-related fields in the USA peaked in the mid 80s at around 40 percent, but by the late 90s this figure had dropped to approximately 28 percent. This is somewhat different to the figures produced by the Information Technology Association of America (ITAA) which publishes results based on data drawn from the Federal Bureau of Labor Statistics. A report published by

the ITAA states that in 1996 women held 41 percent of IT jobs, but by 2004 this share had dropped to 32.4 percent (Information Technology Association of America, 2005).

The discrepancies in these figures are not uncommon as there are no standardised definitions of what constitutes an IT or ICT job. The ITAA report also states that if the women working in administration roles are excluded from the 2004 figures, then the percentage drops to 24.9 percent, which is more closely aligned with the figures reported by Hill.

United Kingdom (UK)

Though the figures for Australia and the USA are less than ideal, they indicate a significantly stronger contribution to the ICT workforce than is found in the UK. The UK Resource Centre for Women in Science, Engineering and Technology lists the participation rate of female ICT professionals at just 14.3 percent in 2003, the most recent figure available at the time of writing. This proportion had dropped three percent since 2001 (Institute for Employment Studies, 2005).

European Union

In 1999, research conducted by Panteli et al (1999, p. 170) found that no member state of the European Union had a participation rate of more than 30 percent, and that most members were closer to 20 percent. These researchers also found that of all the European Union member states, the UK had the greatest rate of decline (Panteli et al., 1999).

The situation at Edith Cowan University (ECU)

At ECU the majority of ICT and LIS related Bachelors' degrees are offered by the School of Computer and Information Science (SCIS). The SCIS completion figures for ICT and LIS related Bachelors' degrees and new enrolment statistics are reflective of the global situation described above.

SCIS Completions

A detailed picture of the trend in completions can be seen from the data for the eleven years from 1994 to 2004, as shown below in Figure 4. These statistics show a significant rise in the total number of completions however the percentage of degrees awarded to women averages just 24 percent and never exceeds 33 percent (see Figure 5 below). If the LIS-related courses are excluded from the figures, the percentage of women receiving ICT-related awards averages just 19 percent and never exceeds 26 percent.

These figures are not reflective of the overall ratio of female to male students at ECU, which traditionally has a significantly larger female student base. Females accounted for over 60 percent of the entire student body in each of the eleven years from 1994 to 2004 (Edith Cowan University, 2005a, p. 3).

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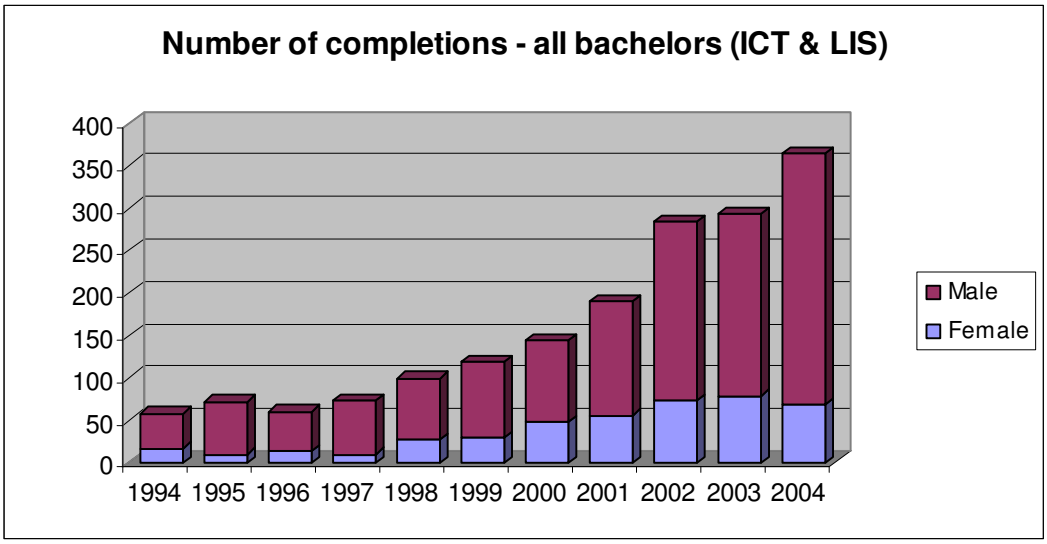

Figure 4 - SCIS Bachelors Degrees: Number of Completions from 1994 to 2004 (Edith Cowan University, 2005b)

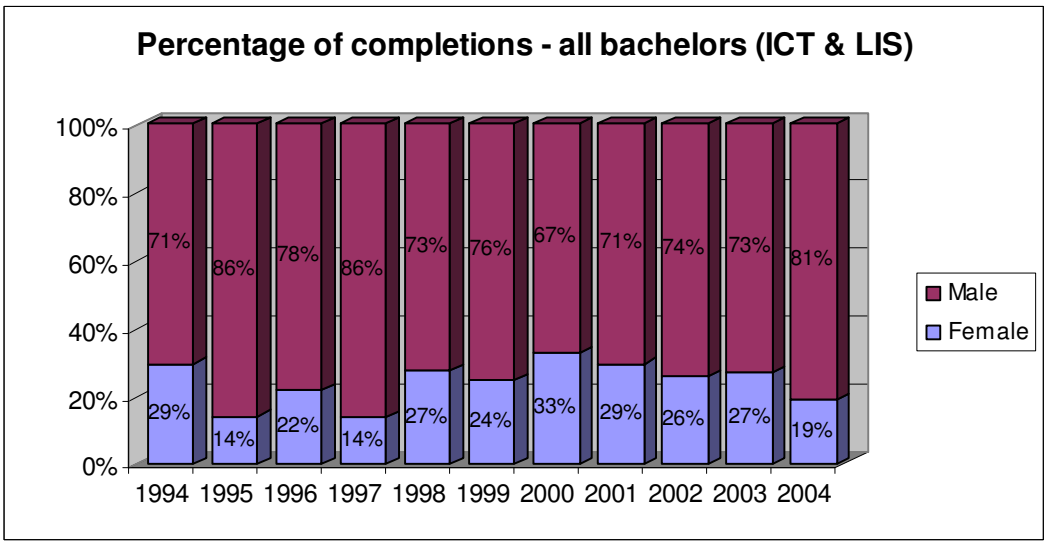

Figure 5 - SCIS Bachelors Degrees: Percentage of Completions by Gender from 1994 to 2004 (Edith Cowan University, 2005b)

Completions by Course

The awards discussed above were all Bachelors of Science or Bachelors of Applied Science; with majors and specialisations in Computer Science (Comp Sci), Software Engineering (Soft Eng), Internet Computing (Int Comp), Communication and Information Technology (Comm & Inf), Information

Science (InfoSci), and Library Technology (LibTech).

The latest completion figures for SCIS Bachelors degrees are for the 2004 academic year (see Figure 6 below). It can be seen that Computer Science had the lowest representation of women with just eight percent of awards going to females, while Library Technology had the highest at eighty-six percent.

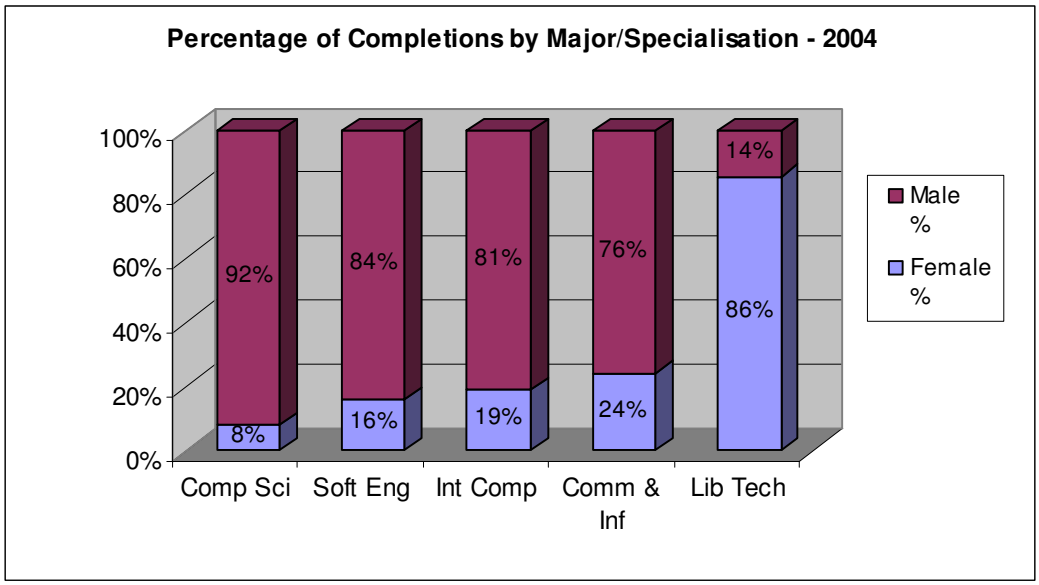

Figure 6 - SCIS 2004 Bachelors Degrees: Completions by Major or Specialisation - (Edith Cowan University, 2005b)

ECU New Enrolments

The completion figures discussed previously reflect the counts and percentages of students at the end of their course. As each of these courses takes three years to complete, this means that the majority of the completion figures for 2004 are for students who enrolled no later than 2001. To get a more up-to-date picture of the current trends in ICT and LIS related courses at ECU, the new enrolment or commencement figures must be looked at.

Figure 7 below shows the total number of commencements or new enrolments for all Bachelors degrees offered by SCIS. This shows a peak for enrolments in 2002, with the overall number of enrolments declining 36 percent between 2002 and 2004.

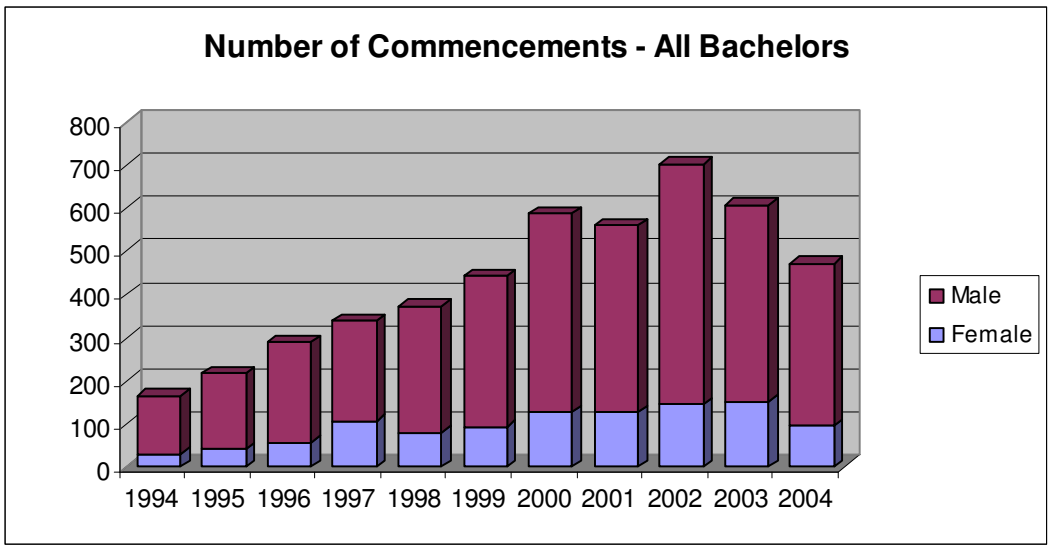

Figure 7 – SCIS Bachelors Degrees: Number of Commencements from 1994 to 2004 (Edith Cowan University, 2005b)

Figure 8 below shows the percentage of new enrolments broken down by gender. It can be seen from this chart that the percentage of females commencing Bachelors' degrees in ICT & LIS related fields has never exceeded 31 percent, and in 2004 dropped to a ten year low of just 20 percent. These figures do not reflect the 2004 commencement figures for the whole university where nearly 60 percent of newly enrolled students were female (Edith Cowan University, 2005b).

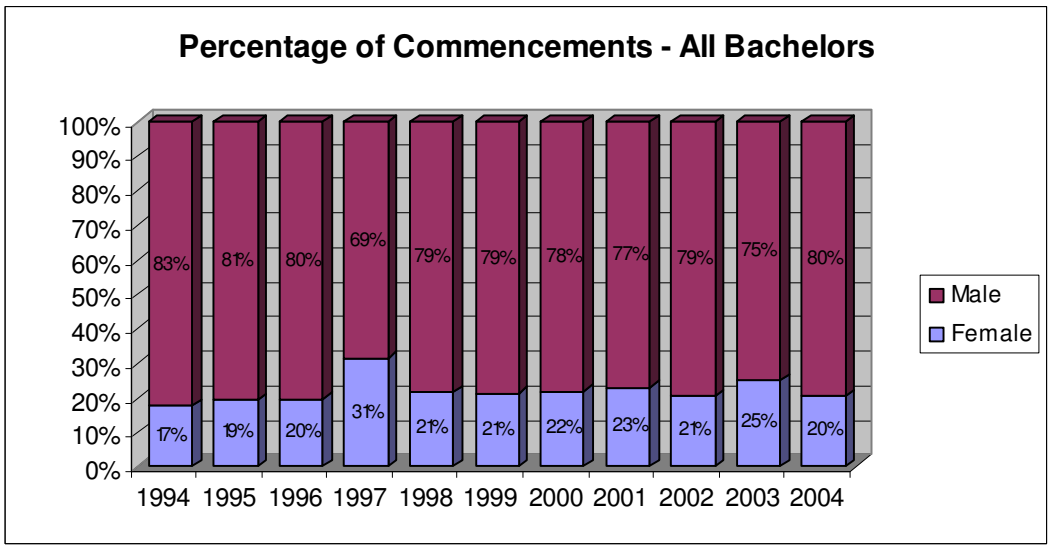

Figure 8 – SCIS Bachelors Degrees: Percentage of Commencements by Gender from 1994 to 2004 (Edith Cowan University, 2005b)

Commencements by Course

The commencement figures discussed above were all Bachelors of Science or Bachelors of Applied Science. Majors and specialisations were as follows: Computer Science (Comp Sci), Software Engineering (Soft Eng), Internet Computing (Int Comp), Network Technology (Net Tech), Communication and Information Technology (Comm & Inf), Information Science (InfoSci), Library Technology (LibTech), and a double-major in Communication and Information Technology and Library Technology (C&IT/Lib).

Figure 9 below shows the total commencement figures from 1994 to 2004, broken down by major or specialisation. Generally, it can be seen that the commencement numbers for Communications and Information Technology and Software Engineering have grown, whilst until 2003, Computer Science stayed fairly constant.

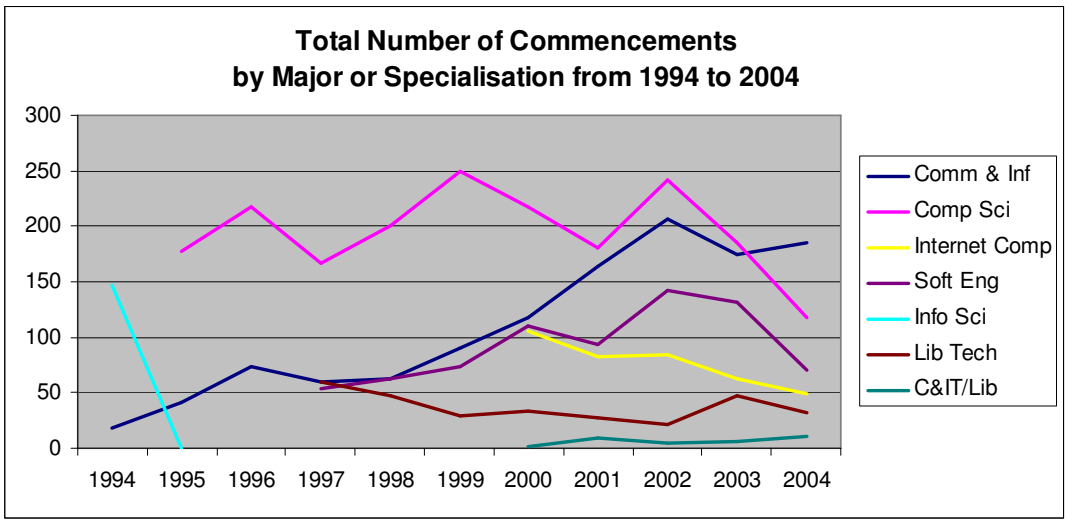

Figure 9 – Number of SCIS Bachelors New Enrolments from 1994 to 2004 by Course (Edith Cowan University, 2005b)

When broken down by gender, the female commencement figures by major or specialisation show a significant growth in the number of females enrolling in the Communication and Information Technology course, whilst the number of women enrolling in Computer Science has dropped considerably over the same period of time (see Figure 10 below). This would strongly indicate that when females do decide to embark on an ICT-related course at ECU, they are choosing less technical courses. The LIS-related courses are also more popular with women than most of the ICT-related courses, though the commencement numbers are somewhat irregular, which makes trend identification difficult.

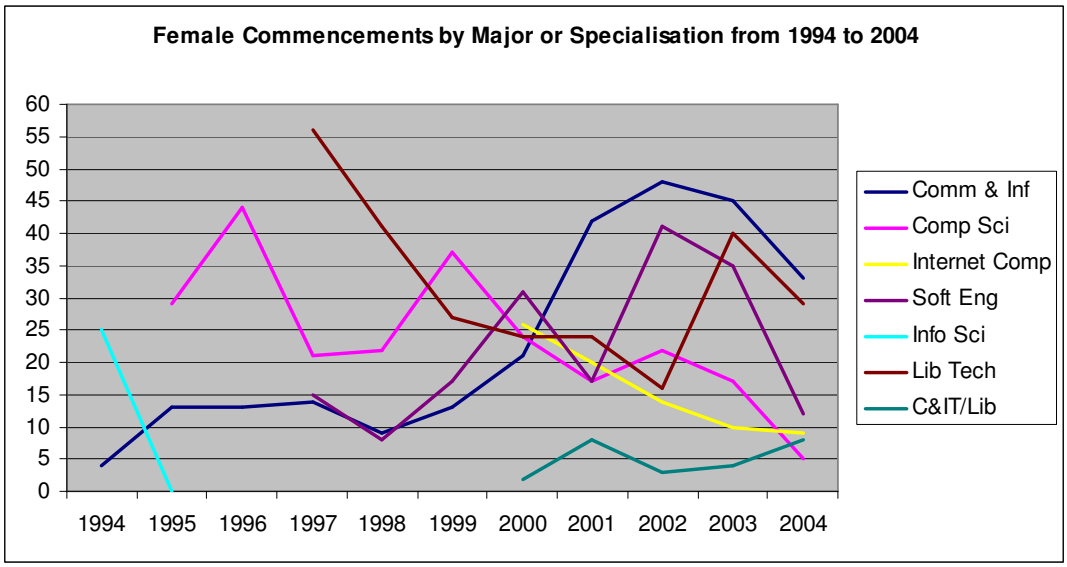

Figure 10 – Number of Female SCIS Bachelors New Enrolments from 1994 to 2004 by Course (Edith Cowan University, 2005b)

The latest full-year commencement figures available for ICT and LIS related Bachelors degrees offered by SCIS are for the 2004 academic year. These figures, broken down by course and gender, are reflected in Figure 11 below. This was the first year that a new course called Network Technology was offered. This course attracted nine students in its first year, all of them males.

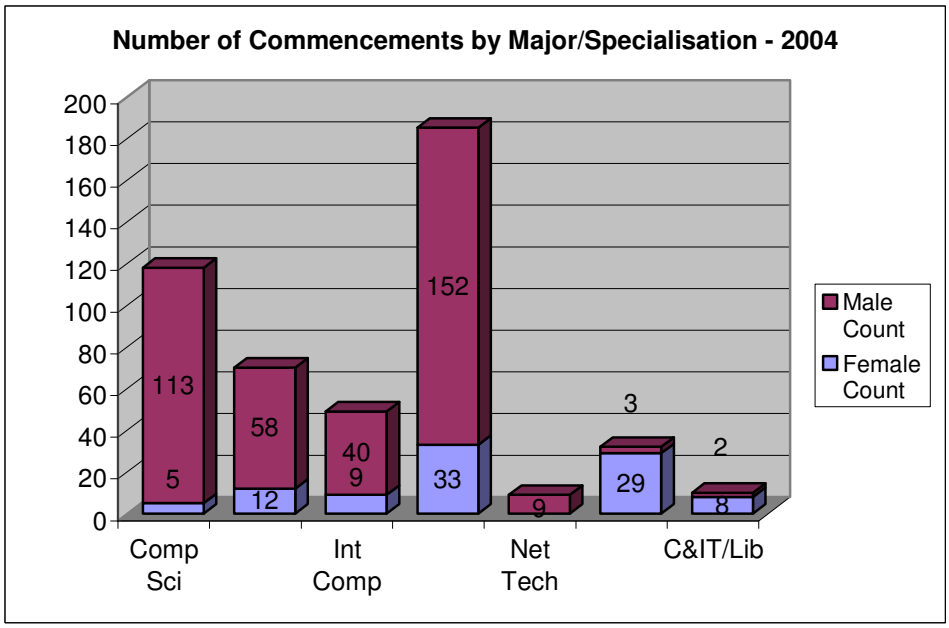

Figure 11 – SCIS 2004 Bachelors Degrees: Number of Commencements by Gender and by Major or Specialisation (Edith Cowan University, 2005b)

This chart clearly shows that apart from Network Technology which had only nine students who were all male, the course with the least number of female students was Computer Science, even though overall it had the second highest total enrolment.

When the male to female ratios are calculated for all 2004 Bachelors degrees offered by SCIS, it can be seen that women make up 80 to 91 percent of all LIS degrees, while women make up between 0 and 18 percent of ICT degrees (see Figure 12 below).

Computer Science and Network Technology have the lowest participation rates. In these courses, which are the most technical of all ICT-related courses offered by SCIS, females represented just four percent of Computer Science students and none of the Network Technology students. What is not apparent from any of these figures is whether these female students make a decision to steer away from the more technical and programming-oriented subjects of the computer science degree, or steer towards the more human and organisational subjects of the other courses.

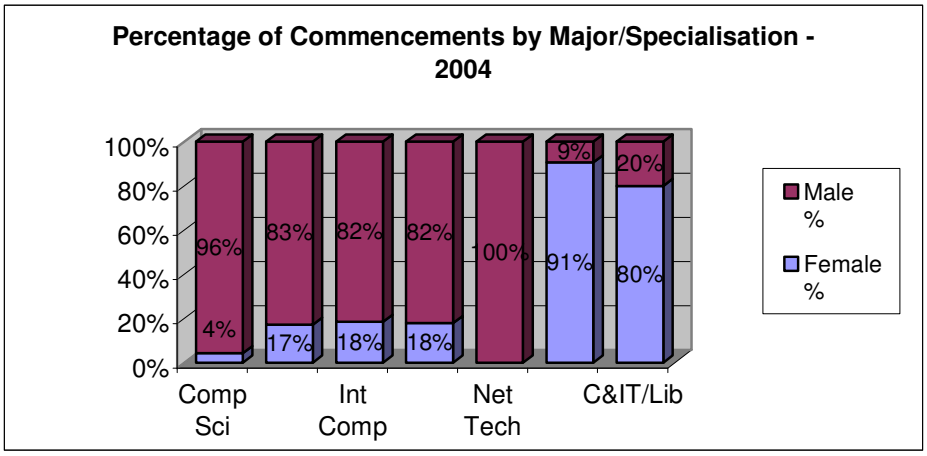

Figure 12 - SCIS 2004 Bachelors Degrees: Percentage of Commencements by Gender and by Major or Specialisation (Edith Cowan University, 2005b)

Computer Science Commencements

Between 1995 and 2004, the number of students enrolling in a Computer Science degree has fluctuated considerably. The peak years for enrolments were 1999 and 2002 with 249 and 242 students respectively (see Figure 13 below).

The gender breakdown of these peak years differs greatly however with 15 percent female representation in 1999 and only nine percent in 2002. By 2004, this participation rate had dropped even further, hitting an all-time low of just four percent in 2004. See Figure 14 below for a complete picture of the gender breakdown of computer science enrollees per year.

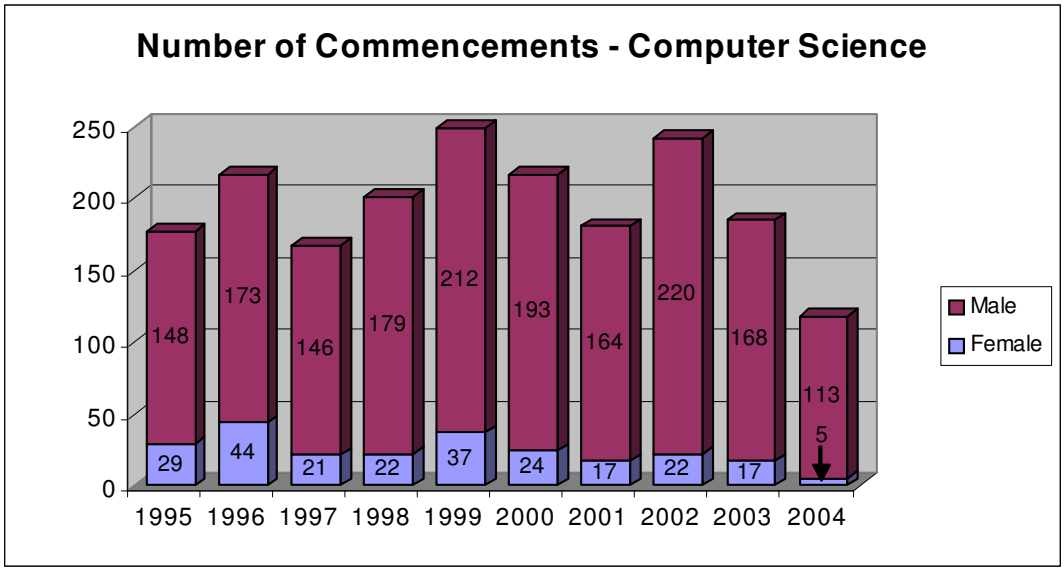

Figure 13 – ECU Number of New Enrolments – BSc Computer Science (Edith Cowan University, 2005b)

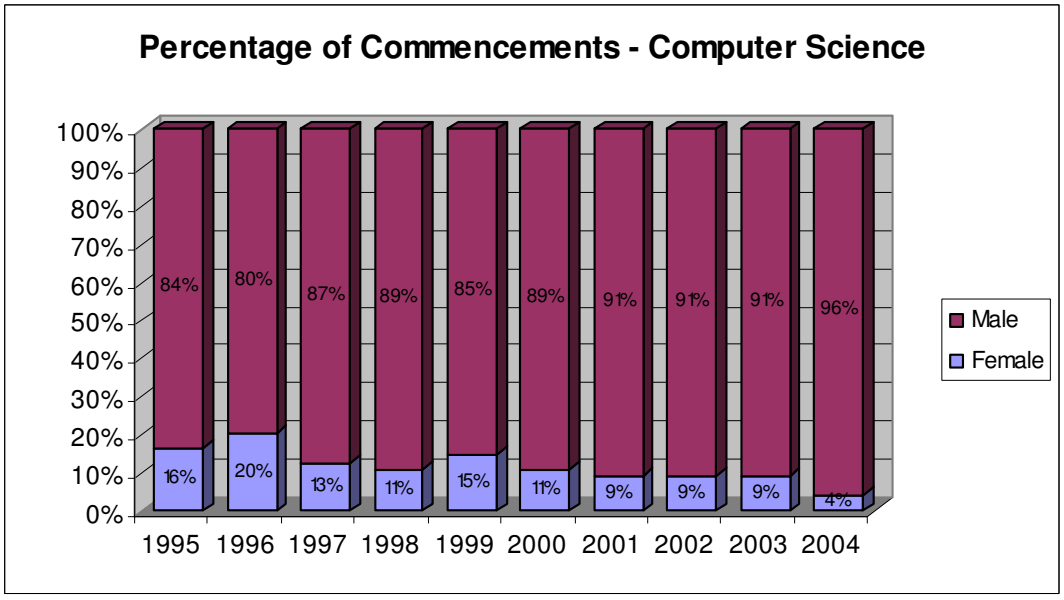

Figure 14 – ECU Percentage of New Enrolments by Gender – BSc Computer Science (Edith Cowan University, 2005b)

When the annual percentages of females commencing Computer Science degrees are plotted separately, the resulting chart clearly shows a decline in the participation of females in this field (see Figure 15 below).

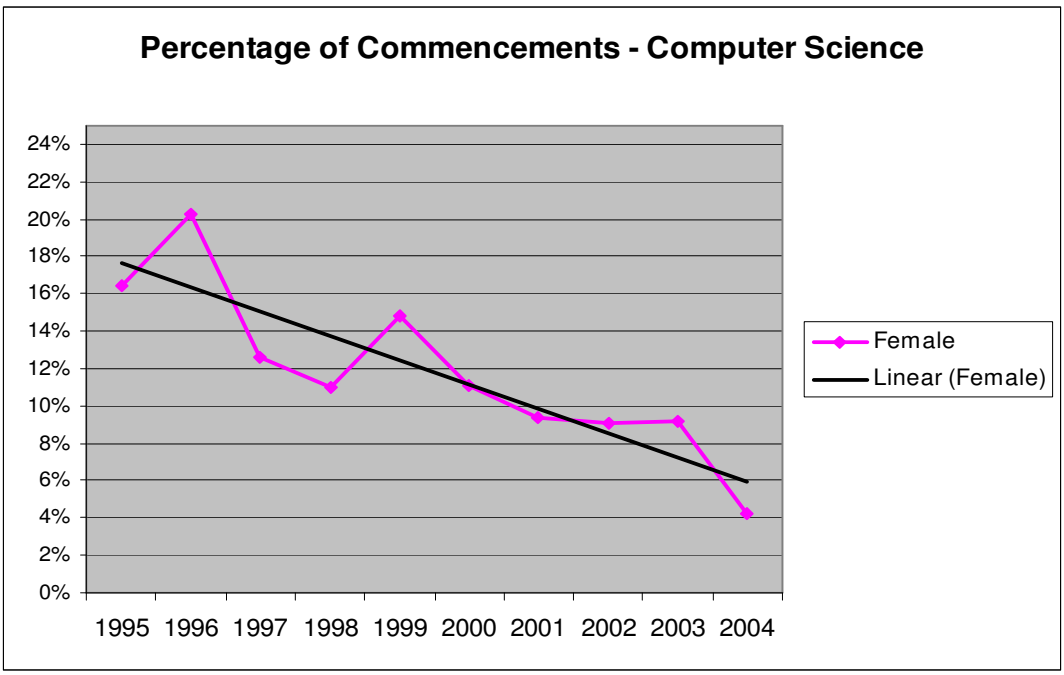

Figure 15 – ECU Percentage of Female Enrolments – BSc Computer Science (Edith Cowan University, 2005b)

ICT and Library and Information Science (LIS)

The Internet in particular has meant a 'significant shift in how information is created, stored accessed and delivered' (Fitzgerald & Savage, 2004, p. 24). The Internet has provided the medium for the storage and communication of what has been dubbed an 'information explosion' (Deegan & Tanner, 2002, p. 237; Witten, 2003, p. 11). Estimates on the rate at which information is "exploding" range from it doubling every 5 years to it doubling every 100 days. Though no-one can agree on the rate at which it is growing, it cannot be argued that the amount of information being produced is growing rapidly (Crawford & Gorman, 1995).

This explosion in the amount of information being created, stored and processed creates a society in which attention cannot be rested on one issue, because no matter how much is read, the mountain of unread material gets larger and larger. In this chaotic world, the 'ability to find information will be increasingly important, the possession of information will be less important' (Lesk, 1997, p. 4).

Librarians thus become even more critical because their skills at information finding and management allow them to create a sense of order and value for the volumes of information that are being generated (Deegan & Tanner, 2002).

The gender balance of those who study and work in the field of Library and Information Science (LIS) is essentially the reverse of the gender balance of those who study and work in ICT. That is, LIS is a female-dominated environment. Providing detailed

statistics about the gender balance in LIS is beyond the scope of this paper, however, some statistics are required to back up this claim.

In Australia, according to the Australian Library and Information Association, 85 percent of library staff are female (2005). Similarly, in the early nineties in Finland, women occupied 90 percent of library staffing positions (Haavisto, 1994). In the United States, according to the results of the 2000 census, females accounted for 71.5 percent of all librarians, and 74.2 percent of library technicians, library assistants and other library workers (US Census Bureau, 2005).

Though there is an overall majority of women in LIS, they are less dominant at higher levels, in management and senior positions. An inquiry into pay equity issues by the New South Wales Government which began in 1998 reported it to be 'noteworthy that, notwithstanding the long history of female domination the highest proportion of male employees is to be found in the two highest classifications' (Bonella, 2003).

Library workers are increasingly required to utilise technology in the execution of their duties. This has also meant a change in the way that library workers are trained and educated. This is apparent in the course outline of current library technology degrees where a large part of the coursework is related to computers and information systems.

In the 21st century, libraries are heavily reliant on information and communication technologies for the production, storage, and communication of information. Libraries, like many other organisations, are becoming dependent on ICT systems for service delivery, the provision of information, day to day management, administration and communication (Fitzgerald & Savage, 2004; Gallimore, 1997).

This increasing dependence on ICT by libraries and education institutions is significant in that men are 'increasingly employed in technology based positions, resulting in occupational segregation along gender lines' (Ricigliano & Houston, 2003, p. 1).

In libraries, ICT is bringing about changes in role definitions, tasks, services and organisational structures. Some professional positions have decreased or have been reallocated to accommodate new kinds of technical expertise (Ricigliano & Houston, 2003). For example, between 1991 and 2001 in academic research libraries in North America, the number of technical specialists doubled, while cataloguers and heads of serials departments dropped by 25 percent and 35 percent respectively (Ricigliano & Houston, 2003, p. 3)

Conclusions

At ECU, the decline in the participation of women in ICT-related fields is most obvious in the new enrolments in Computer Science. For those people working in the areas of design and development of new technology, a background and/or degree in Computer Science is common, and in many cases required.

It has been shown that workers in the field of Library and Information Science (LIS) are becoming heavily dependent on technology to carry out their duties. This indicates that the diversity of the

people developing technology is at odds with the diversity of the people employing technology.

The extent of any impact on LIS from a lack of diversity in ICT cannot be predicted, however if the values of the people who are adopting and using technology are not incorporated into the design of the technology, there is a significant risk that the division of labour will become increasingly gendered.

This may increase the decline of interest in young people, especially women, pursuing a profession in the field of Library and Information Science, which as a field is already 'an aging, immobile workforce, struggling with the impact of and difficulties in implementing and promoting use of new technology' (Fitzgerald & Savage, 2004, p. 29).

In an ideal world, technology would be useful, intuitive, easy to use, cost effective, and behave consistently. With too much focus on technology and not enough on the needs of users, this ideal is getting further away. Increasing the diversity of the teams designing and developing technology may bring us closer to this "techtopia".

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