AN INCONVENIENT TRUTH: THE INVISIBILITY OF WOMEN IN ICT

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ABSTRACT

This paper presents research findings from an Australian Faculty of Information and Communication Technology (FICT) against a backdrop of declining interest amongst women in courses and careers in Information and Communication Technology (ICT). It poses the question of why research conversations around women in ICT are still pedagogically ignored, even after over twenty years of gender research and projects. In reporting the findings of this research project it seeks an understanding of and remedy for the steep decline of interest and uptake of ICT places at tertiary institutions in Australia, particularly amongst young women. In addition to understanding gender differences in educational motivation and performance, and appreciating the challenges posed to ICT education, readers must also be cognisant of the steep decline of interest in careers in ICT in general.

INTRODUCTION

The 'Women in Information Technology – Swinburne' Project (WIT-S) is a three-year research project at Swinburne University of Technology aimed at gaining a deeper, conceptual understanding of the gendered participation in Information and Communication Technology (ICT) education as the basis for informed intervention at a range of levels. The whole area of the relative lack of diversity in ICT education and careers has been under-theorised in both the literature and at the level of

assumptions underpinning recruitment and retention projects in ICT and science, engineering and technology education (SET) more broadly (Trauth 2006). WIT-S is underpinned by the research knowledge that women and men have differential experiences and interactions with the curriculum and teaching environments and with computers (Crawford and MacLeod 1990, Mahony and Van Toen 1990, Cobbin 1995, Collins et al. 2000, Margolis and Fisher 2002, Barker and Aspray (2006). The WIT-S project was originally informed by the multilayered intervention project at Carnegie Mellon University (CMU) in the US where the numbers of women studying computer science were dramatically improved following a range of successful interventions (Margolis and Fisher 2002). Whilst the WIT-S program is geared towards the under-representation of women in tertiary ICT education, the project is also designed to widen the appeal of ICT to 'non-geek' boys as well as more girls as the ICT sector faces declining student numbers overall in post-secondary education.

At one level the WIT-S project is part of the next generation of gender and ICT projects in the Australian university system after an earlier 1980's generation of projects and reforms (Cobbin 1995). However, this WIT-S gender project at Swinburne's Faculty of Information and Communication Technologies triggers a much wider set of issues concerning gender research projects and their findings more generally in the higher education sector both in Australia and internationally over the past 20 or more years. Whilst located at and funded by Swinburne University of Technology, the project could be in most Australian and indeed overseas universities where the drop in student interest in studying ICT and the subsequent downsizing and amalgamations of ICT teaching units have become commonplace (Lang et al. 2005, Charles and Bradley 2006). Throughout this paper ICT will be used to represent all variations in specialisations within this discipline, including Information Systems, Computer Sciences, Information Technology and other computing courses. WIT-S is focused on understanding the gender differences in learning and studying ICT for the benefit of our University and our corollary aim is to contribute to a more cohesive theory about why women are 'deserting' ICT education at a higher rate than men and take a fresh look at strategies for interventions in higher education.

Historically, when there are crises in procuring sufficient numbers of undergraduate students in the SET curriculum areas in general, the 'what about the women?' issue commonly appears (Wacjman 1991). Historically, this concern about numbers of women has been driven by policy notions of social and economic justice for women (Cobbin 1995), but the flow of funds for short-term projects such as WIT-S have waxed and waned over the past 20 years in the Australian tertiary system. Long-term funding for equity research, policy and program level responses is very rare indeed in Australia with few universities maintaining their commitment over time. Currently, these questions 'about the women' also coincide with prosperous economic times nationally and together create the possibility of some innovative responses to this research. The national prosperity in Australia however contrasts with a university sector that is seriously under funded by international standards (OECD 2007) and it is difficult to see where the circuit breaker will occur as high quality and equitable education will require appropriate resourcing.

Unlike secondary and primary education in Australia (Yates 1993; Murphy and Gipps 1996) there has never been a system-level focus on understanding what gender and culturally inclusive education means in SET and ICT education at the tertiary level despite the continuing low numbers of women in these courses at many of our universities (Lang et al. 2005, DEST 2006). Whilst equity based research in the primary/secondary sectors have seesawed with political changes in State governments, funding for system-level equity-based research and pedagogical reviews in the post-secondary sector have been neglected by successive federal governments. ICT faculties, and indeed SET university faculties in general, rarely have the resources to investigate which groups of girls and which groups of boys have access to or are achieving in their curriculum, teaching and assessment practices (Littleton 1996, Furger 1998, Durndell et al. 1998, Meredyth 1999, Collins et

al. 2000). An ICT education at an Australian university undoubtedly provides an opportunity for students to gain access to an economically beneficial career and the critical questions about who benefits and does not benefit in the current system are rarely asked. Related to this pattern, we are hypothesising that the evidence based and reproducible research findings focusing on the gendered ICT classroom over the past 20 years have been rendered largely invisible in tertiary institutions.

Pedagogical practices of academic staff are fundamental to how teaching and learning enhances or undermines student learning and achievement in the ICT classroom (Ramsden 1998). The three 'message systems' of education are commonly described as curriculum, pedagogies and assessment (Bernstein 1971). All these 'message systems' need to be research based and, we argue informed by gender theory as well as the traditional educational and discipline-based knowledge that underpins ICT education. Our experience, and the learnings of gender theory itself, suggests that unless equity issues have an active role and contribution in both policy and practice terms within ICT faculties, then intervention programs and their findings will continue to be marginalised and rendered invisible through the hidden faculty processes that maintain the traditional gender order (Connell 1995, Connell 2002). Currently, most tertiary institutions do not question the way the 'gender order' is institutionalised within faculty processes such as curriculum and teaching decisions, course design and selection, sequencing of subjects within courses, course evaluation and review processes and teaching and assessment practices. Gender theory informs us that there is a regime of gendered social relations that operates in everyday relationships, committee structures, email exchanges and committee processes in organisations that devalue and ignore gender learnings and questions (Eveline 1994; Fletcher 2001, Adam et al 2004). Whilst ICT education started well in the 1980's when relative numbers of women students were higher than other SET curriculum areas, the steady decline in numbers of women choosing ICT education and careers has not as yet resulted in a system-level response.

In the tertiary education sector in Australia, unlike the US (Cohoon and Aspray 2006) and the Greenfield Report in the UK (Peters et al 2002), there has not been any professional review of ICT education at the teaching, curriculum and assessment levels in response to either the significant cultural diversity issues facing the sector or the continued decline in the gender balance. There is little historical base to understand the gender, class and cultural components of ICT education and the traditional and hidden social practices embedded in teaching and learning ICT (Meredyth 1999).

Senior women in male dominated workplaces experience more strongly sexualised gender stereotypes and roles in the workplace (Fletcher 2001; Kantor 2003) and this appears to spill over very directly into curriculum and teaching decisions in male dominated faculties where the gendered nature of curriculum and teaching needs to be considered (Cobbin 1995; DEST 2004; James et al. 2004). The educational processes within ICT faculties and teaching units support the existing ways of doing curriculum, pedagogy and assessment and do not usually allow for curriculum review and reform. There is considerable disjunction between the research based findings that live in the knowledge and practices of many academics that have researched and considered the gender and ICT educational learnings and the invisibility of these learnings in faculty processes (Trauth 2006). We will describe some of these below.

The intent of this paper is to bring to the fore conversations about gender-based research findings within ICT in higher education. It is an inconvenient truth in ICT education that the findings of gender-based research over the last twenty years have been ignored, and now the ICT discipline is facing a crisis in student numbers. Women in ICT, while visible statistically, have been rendered invisible in the gendered organisational context of these faculties. Not all women ICT students have the same teaching and learning needs, however there are broad gender-based trends that point to a diversity of student needs that are not understood or recognised in most ICT faculty pedagogies. In this paper, we will first consider the crisis in ICT enrolments at university which in part motivated

this research project, and then the under-representation of women in ICT courses. The paper will then broadly discuss a range of gender issues and how these impact on educational contexts, particularly in under-represented areas of education for women, including ICT. We then consider some of the local research findings, which, using terminology adopted by Cohoon and Aspray (2006) we have called 'Things we already know' at Swinburne. This synthesis of theoretical knowledge from the literature and findings form our empirical work are finally discussed with our key recommendations.

THE CRISIS IN ENROLMENTS

First to the crisis in enrolments in ICT. There are analyses elsewhere about the recent downturn in student numbers (Lang et al. 2005; Lewis et al. 2006) despite the seemingly contradictory evidence of the skill shortage in the ICT industry. Whilst the percentage of women participating in ICT courses at Australian universities has fluctuated according to the specialisations within the discipline, apart from the three years after 1997 when there was a growth in aggregate female enrolments of an average of half a percent per year, there have been declining female enrolments for 20 years (Lewis et al. 2006). From 2000 to 2005, the popularity of the ICT discipline has plummeted in Australia with fewer women and men entering the ICT field at university: there has been a decline of 29 per cent in males, and an alarming 51 per cent decline for women. The aggregate proportion of females enrolling as new undergraduate ICT students in Australian universities has also declined from 26 per cent in 2001 to 20 per cent in 2005 (DEST 2006).

We are hypothesising that this is no 'new' crisis at all in relation to the participation of women in ICT education but simply a further consolidation of a pattern that has been evident for 20 years. As early as 1995 a national study of 'women's participation in non-traditional fields of study' concluded that computer science in Australia was the one field of study that had shown a decrease in the representation of women during the study period 1989 to 1994 (Cobbin 1995). The 2004 equity review of 'non-traditional courses' in Australian higher education concluded that ICT should be retained as a non-traditional field of study equity group with targets of 40% participation for women (James et al. 2004).

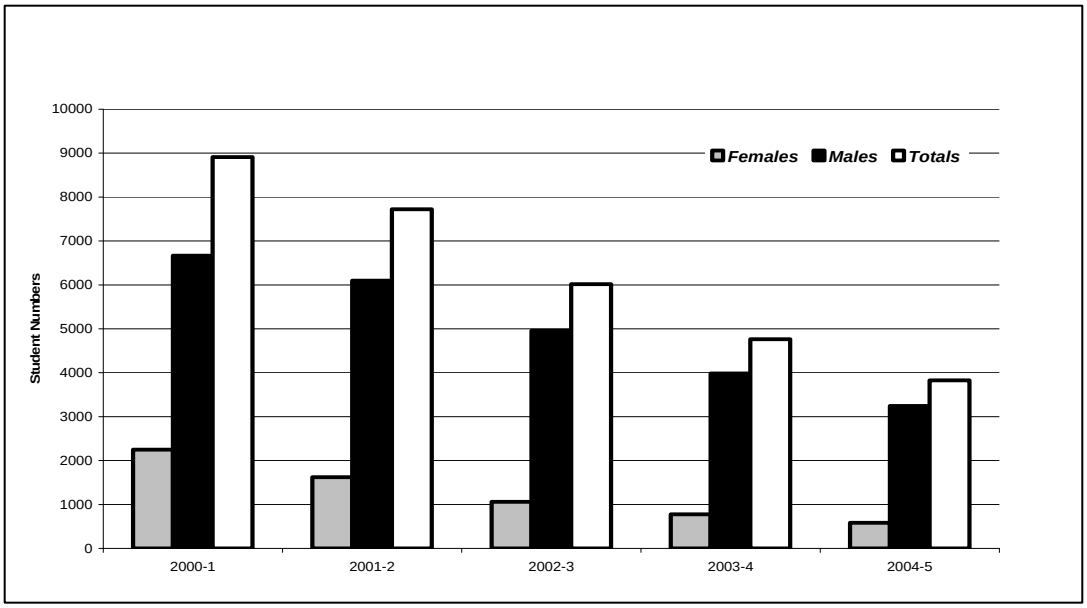

Figure 1: IT courses as first choice university course selection (VTAC 2006)

At a time when the overall participation rates of women in higher education in Australia have increased to 56.7% of all students in 2004 (DEST 2004), and disciplines such as medicine and law have more than 50% undergraduate women (medicine 57% in 2003, law more than 50% since 1996), female aggregate enrolments in ICT courses have decreased to 20% overall. Since 2001, ICT has witnessed a 46% collapse in the number of students selecting ICT courses as their first preference for higher education in Victoria (VTAC 2006, Figure 1). When this figure is analysed by gender, there is an overall decline in ICT course selection of 65% amongst females compared to 40% amongst males (VTAC 2006). With the overall participation of women in the ICT field of study close to 20%, this leaves many ICT courses and year levels with cohorts of women far less than 15% (DEST 2006).

Interestingly, Australia also reflects the global downturn where the numbers of women enrolling in ICT courses at universities in western industrialized countries has also been spiralling down over the past two decades. Wright (1997) surveyed the numbers of women studying in ICT /computing courses between 1985 and 1990 in 19 countries and found that 12 countries – including the US and the UK – witnessed a decline during these years (Wright 1997). The number of women studying in all ICT/computing courses in the UK fell from 28% in 1990 (Wright 1997) to 18% in 1999, and this decline has continued in more recent years (UCAS 2005). A recent international study of the proportional gender representation in the discipline carried out by analysing graduation trends from twenty-one industrialised countries emphasised the widespread masculinity of the field (Charles and Bradley 2006). However there was disparity between countries in the degree of over-representation of males. The male to female ratio was three times stronger in some countries than others (Charles and Bradley 2006 p.191). The male 'over-representation factor' was the lowest for Turkey (1.79) and the highest for Czech Republic 6.36, with Australia low at 2.86 (Charles and Bradley 2006 p.190).

THE GENDER AND ICT JIGSAW

Few ICT faculties employ staff with specialist expertise in education or gender theory and herein lies some of the dilemmas underpinning our broader argument about the invisibility of previous research into ICT education and the related tendency to reinvent the wheel. Gender is a critical element in the gender/class/culture socio-demographics in shaping our social and organisational lives and all our social interactions. As Collins, Kenway and McLeod (2000) outline, the socio economic differences within groups of boys and within groups of girls can outweigh the gender differences; for example socio economic status (SES) makes a larger difference than gender to educational participation and Year 12 performance in Australia (Collins et al. 2000). Contemporary thinking in gender and education is more concerned about the 'which boys, which girls?' approach to understanding differences in educational outcomes as an important development in thinking about difference (Collins et al. 2000). The so-called 'gender wars' or 'gender gap' has kept the public debate within the binary 'boy versus girl' discourse rather than as Collins et al (2000) advocate, into understanding the gender jigsaw. To understand the 'gender jigsaw' the argument needs to move beyond a binary 'boy versus girl' discourse to an understanding of why ICT is not attractive to a greater cohort of students, male and female (Collins et al. 2000). Equally, it is important to avoid using essentialist language that treats all young women and young men as having identical educational needs: hence the importance of asking 'which girls, which boys?' in relation to educational access and success.

However, it is not only the gender differences that are important to educationally understand but the privileging of characteristics associated as masculine over characteristics associated as feminine that is even more important (Adam 2004, Wacjman 2004, Trauth, 2006). In addition, how these differences get translated into advantage and disadvantage in tertiary institutions is also critical (Acker 1990, Eveline 1994). Consequently, we need to understand and review the organizational and educational processes that shape this very valuing of the masculine over the feminine if we are to change anything substantial in our staffrooms and classrooms (Wacjman 2004, Webster 2005). This includes our hypothesis that gender research findings are themselves not valued historically in informing and determining change in relation to curriculum and teaching of ICT. We will return to this theme when discussing our findings.

It can be problematic to regard ICT as a 'single' discipline, as the juxtaposition of 'information', 'communication', and 'technology' suggests some sort of separation of interests. The predominant focus, particularly in the earlier years of the discipline, was on the technology itself, and saw the development of a range of technical theories, frameworks and practices geared to underpinning the technical challenges, generally at the exclusion of social theories and practices (Mahoney and Van Toen 1990, Adam et al. 2004). More recently, there has been greater focus on information as an organisational resource, and in the more information-oriented sub-disciplines in ICT, namely information systems and information management, there has been an increasing emphasis on both the technical, and social theories and practices (Adam et al. 2004). Indeed the ubiquitous application of ICT to all aspects of society and its increasingly 'human' focus should necessitate a greater investigation as to how to configure the discipline to be attractive to an increasingly diverse, yet diminishing cohort (Trauth 2006). The contradiction that emerges in contemporary ICT higher education is that student numbers mean economic survival for faculties, yet in an era of declining enrolments, we hypothesise that ICT faculties still marginalise 'diversity' projects, and overlook strategies that are informed by research and would attract and retain a larger cohort of students - both men and women - to the discipline.

During the 1980's and 1990's, most of the 'access and equity' discussions in ICT in higher education were centred on recruitment where outreach programs targeted young women in schools to consider ICT as a career (Cobbin 1995; Sandler et al. 1996). These models ultimately carried an assimilatory set of assumptions: influence young women to change their choices and then they would participate in the same university courses historically offered to men, and they would be indistinguishable from the male students in their curriculum and teaching needs. Women had no choice but be assimilated into a male dominated faculty, and theorists have argued that this required women to 'become one of the guys' in terms of their gender identity in ICT and other densely masculine disciplines (McLean et al. 1997; Wacjman 2004). These 'first generation' intervention programs were largely based on a liberal discourse of equal opportunities similar to the WISE (Women Into Science and Engineering) initiatives since 1984 in the UK (Henwood 1996). This discourse inadvertently placed the responsibility on women who were seen as ignorant of the opportunities and choices that 'non-traditional' education and careers had to offer (Henwood 1996). Consequently many universities designed recruitment and retention programs directed at 'informing' women's choices but the parallel challenge of changing curriculum and teaching practices as well as cultural changes inside the ICT academy was overlooked. There was not a corollary lens on how ICT and its institutions could be reshaped to accommodate rather than assimilate women into existing structures and cultures.

Many of the findings of gender and ICT projects, like WIT-S, have been found before in earlier ICT education research contexts (Margolis and Fisher 2002, Cohoon and Aspray 2006, Trauth 2006). During the 1990's, there was a proliferation of literature about why these secondary and tertiary courses acted as an unwelcoming learning environment for women (Cobbin 1995; Murphy and Gipps 1996; Sandler et al. 1996). Common criticisms of ICT education focus on the over-emphases on abstract 'mathematical formalism' (Mahony and Van Toen 1990) and on the technical skills (Cohoon and Aspray 2006). Different mathematics choices operate at school for girls and boys and career options for girls, given their more limited subject selection in secondary school, can be more restricted (Cobbin 1995). In the 1995 review of the 'non-traditional' fields of higher education study, Cobbin (1995) cited the following reasons from the literature for the differential participation of girls and boys in ICT: sex stereotyping of toys and activities; sex-biased computer software and games; differential availability of female and male role models; different learning experiences of girls and boys in the gendered classroom where boys' had greater access to school resources and teacher attention. Other frequently cited reasons for women choosing not to enter ICT education in the same numbers as men are: the construction of the ICT curricula as abstract and disconnected from social and human concerns; software being written by and for men and boys that results in greater informal exposure of boys to ICT; domination of computer training programs by boys, men and male values; and the perceptions of computer professionals as geeks, nerds and antisocial 'computer heads' (Cobbin 1995, Cohoon & Aspray 2006). There are also differences evident in self-confidence, self esteem and risk taking behaviours of young women and men (Eckel and Grossman 2002; Gneezy et al. 2003). Indeed recent studies confirm that knowledge and understandings of the technical at the expense of the socio-technical, 'real-world' and relational skills is still predominantly valued in most ICT faculties (Margolis and Fisher 2002, Cohoon and Aspray 2006).

There is even less discussion of the importance of informal learning in the production of these gendered patterns. Tully (1997) examined informal pathways to computer knowledge and argued that while 'the knowledge of how to handle a computer should be taught mainly via the school education system', in reality 'the acquisition of computer skills is primarily ensured by informal learning in the home' (Tully 1997). Students attitudes to and competence with computers in the

classroom are related to at-home access and that most learning about computers occurred at home for those students who had home access (Kersteen and Linn 1988; Martinez and Mead 1988). This theory was verified by the national 'Real Time' study where informal learning was the primary means of learning the information technology skills possessed by both Australian teachers and students (Meredyth et al.1999). The 'Real Time' study also confirmed the digital divide where boys had more access to and spent more time developing ICT skills at home than girls (Meredyth et al. 1999). If the home is the primary means of learning ICT skills, then schools and universities need to include this understanding in the way they design and market ICT courses, for example providing different entry pathways to degree courses to overcome these pre-existing patterns of inequality of access and experience and recognise difference in the cultural and gender backgrounds of students.

All these studies of home, school and university use of computers are overshadowed by the literature theorising the very gendering of the industry and the technologies themselves (Wacjman 1991; Wacjman 2004; Webster 2005). Wacjman and Webster have argued that the very technologies around us are socially shaped as masculine because over time the "culture of masculinity is conterminous with the culture of technology' (Wacjman 2004). As Wacjman explains, it makes no difference whether women or men apply and use the technology - it is the technology itself that is now gendered (Wacjman, 2004). This gendering of technologies means that the current flight of young women from ICT education will embed the more serious structural employment inequalities that surround the numbers inequalities. It reinforces and reproduces the sexual divisions of labour in our society and renders the ICT sector sex stereotyped at best and excluding women at worst.

'THINGS WE ALREADY KNOW' AT SWINBURNE

Here we summarise the Swinburne research findings and our realisation that most of these research findings are already well substantiated in the literature. An important question for faculty learning is how gender influences learning in our ICT classes and the following summary outlines the key findings from our quantitative survey of over 700 first year undergraduate students across the ICT Faculty and the five other University Faculties. The goals of this survey were to glean a better understanding of the student experience, and their attitudes to ICT; their backgrounds in terms of experiences with ICT both in educational and social contexts, their perceptions of courses and career choices, and their experiences at university. More detailed data on the survey results are included elsewhere (Lang et al. 2006; Lewis et al. 2006)).

The summary findings from the WIT-S quantitative and gender audit components of our project lead us to make a list of 'things we know' at Swinburne using the terminology coined by Cohoon and Aspray (2006) when reviewing the research on women's participation in postsecondary ICT education. The 'things we know' at Swinburne are:

The ICT class of 2005 are diverse and have non-traditional pathways to study:

> The question about 'which girls and which boys?' study ICT at our University show some interesting gender and culture patterns for the 'class of 2005'. A high proportion of the women were overseas students (48%) compared with only 18% of the men. Of the 52% of women resident in Australia, nearly 30% were bridging from Technical and Further Education (TAFE) courses, revealing low recruitment of young women directly from secondary school. Only 8% of females compared with over 50% for male undergraduates came to university ICT courses directly from high school. There was also an interesting pattern of single-sex secondary school education for a high percentage of first year ICT

> women (42%) compared with the men (27%) with the majority of these from non-elite private schools.

Male ICT undergraduates have more programming experience prior to university:

> The overall finding was that male and female ICT students have more in common with each other about their experiences of using computers at school, home, and at university than not. Using a one-way analysis of variance, the only statistically significant variance between the genders relating to computer use (using a Likert response to statement about programming experience) was that male ICT students as a group arrive at our courses with significantly more programming expertise and experience than new ICT female students (p.002). As discussed later this was the same finding that led Carnegie Mellon to introduce different entry pathways for different students. Both female and male ICT students significantly differed from the rest of the university students surveyed in their responses about computer use and indicate a greater competence and confidence with ICT for both the women and men undergraduates (p.000), as would be expected with students enrolled in undergraduate ICT courses. Male ICT undergraduates were also significantly more likely to assess coursework timing as adequate to understand the coursework (p.003) and expressed more confidence in their computer skills when compared with their male friends compared with our women ICT undergraduates when compared with their women peers (p.003).

Women experience more stress in transition to university life:

> Our survey asked the first year students a number of questions related to their first-year experiences. Women and men responded similarly on a range of questions related to the climate of the ICT classroom or laboratory but differently in their attribution of course progress and success. However, significantly more women than men thought the course workload was 'heavier than expected' (p.003) and more men than women agreed that 'the coursework timing is adequate to understand the things we have to learn (p.003)' suggesting a proportionately higher number of stressed female students in their transition to university study. Anxiety levels show a further gender difference with more women than men feeling anxious about how they are coping with study compared with the men. Our male ICT undergraduates reported significantly more difficulty balancing their time between study, work and social activities (p.034) compared with women. The data however shows male ICT students undertaking more paid employment during semester and these data may relate to these longer paid work hours.

ICT classes are more disruptive than other faculties:

> There was statistical significance in the responses of both women and men students to questions related to disruptive student behaviour in ICT classes compared with students in other faculties (p.000), indicating a level of disruptive behaviour in the ICT laboratory that supports the well-documented culture of masculinity or 'clubhouse' environment associated with ICT (Margolis and Fisher 2002). It is also evident that our male students have stronger self-efficacy related to their ICT abilities than our female students and that the climate in our classrooms is less than desirable for a considerable proportion of our students.

Pedagogical factors detrimental to student achievement:

> On the basis of the gender audit of student achievement for the 2005 first year ICT cohort, a range of pedagogical factors were significant when clustered together (Lang et al. 2007). When a low female critical mass was combined with no female teaching staff, a masculinised disruptive environment resulted which was detrimental to the learning outcomes for the

> women students. The three aspects of pedagogy shown to significantly affect all students performance were a contextualised curriculum as apposed to an abstract curriculum, varied assessment tasks including continuous assessment as apposed to exam based assessment and faculty teaching by academic staff with teaching qualifications compared with no teaching qualifications (Lang et al. 2007). Interestingly two lowest performing subjects where students received a fail more than any other mark were the two programming subjects in 2005. These subjects had the lowest participation by women (8%) and were almost exclusively taught by male staff with no formal teaching qualifications.

In the recent review of the research on women's participation in post-secondary ICT education Cohoon and Aspray (2006) conclude that we are 'closer to the beginning than to the end of research into the gender imbalance in postsecondary computing education' (p.170). Cohoon and Aspray (2006) created two interesting tables based on their critical review of the literature; 'things we know' (p.171) about the gender composition of ICT and also include another table on 'things we believe and expect to establish' based on their literature review of the research available (p.172). We have separated the Cohoon and Aspray (2006) list into factors connected to student background and factors connected to faculty interventions. From their extensive review of the research in women's participation in post-secondary ICT education, their list of the 'things we know' related to student background are (Cohoon and Aspray, 2006, p 171):

> Computing culture is masculine. Whether it has to be masculine, and whether the culture is a cause or a consequence of its gender composition, are different questions
>
> ICT specialisations have different cultures and gender compositions
>
> Women generally reach college with less programming experience than men
>
> Computing experience has a positive effect on both computer science education grades and confidence
>
> Women generally have less confidence than men in their ability to do ICT
>
> Differences in academic fitness are at most weak contributors to women's under-representation

These review findings are reinforced by our University based research and similar to the CMU study findings that helped shape our WIT-S project, where a 'roller coaster of uncertainty and doubt' was experienced by many of their female students, particularly in the early stages of their course (Margolis & Fisher 2002). These data show a marked similarity with other findings of the gendered student undergraduate experience of ICT curriculum and teaching as well as the CMU findings (Clegg et al. 2000; Margolis and Fisher 2002)) where the ICT classroom experience contains different gender dynamics for the women and men studying in our University. Women are often part of a 'minority' below the critical mass of 15% participation: this percentage was adopted as an earlier yardstick in the study of male dominated educational settings (Cobbin 1995). However research in the business field placed the critical mass at 25%, where Valian found that "when women are in a minority [less than 25%] they are judged more in terms of their difference than their ability, … being in a minority increases a woman's likelihood of being judged in terms of her difference from the male majority, rather than in terms of her actual performance" (Valian 1999 p.140). Kantor (2003) describes the cultural dynamics for women under 25% of a cohort in employment as being judged as a representative of their sex rather than as an individual. In such situations, it has been argued that the environment is 'skewed' towards men feeling comfortable and being able to determine the cultural and classroom dynamics in positive or negative terms (Margolis & Fisher 2002, Kantor 2003).

The ICT and education research literature now provides evidence of the importance of students' perceptions of relevance and the socio-technical contextualisation of the curriculum. A large scale Australian study of 16-year-old science students reported their studies in science as rarely relevant

and not connecting with their interests and experiences (Goodrum et al. 2001). A Victorian Government sponsored project found that many 17 to 19 year olds stereotypically believed the ICT career path to be too boring to consider as a future career option (MMV 2004). This evidence points to ICT faculties needing to move from the content driven to context driven curriculum. The teaching of abstract concepts disconnected from the interests and lives of students has been roundly criticised in a recent review of physics research in education in the UK (Murphy & Whitelegg, 2006). In this review, instigated by the UK Institute of Physics in response to plummeting numbers of post compulsory physics students Murphy and Whitelegg (2006) conclude that changing the curriculum is not simply the addition of applications on the end of a theory lesson but the reconstruction of the curriculum as *context driven* and not *content driven* that is important. It has been well established that girls more than boys engage with learning and teaching when the curriculum is contextualised and the relevance clearly established (Boaler 1997, Murphy & Elwood 1998).

However, context curricula has been curiously under-theorised and researched as a curriculum model. Aikenhead (1994) defined context curricula as 'an organiser' for contemporary curriculum transformation and Murphy and Whitelegg (2006) outlined the characteristics of a context curriculum from their exhaustive review of research into physics education. Context curriculum is where social situations organise and determine the content studied and assessed; the situation and the problems within it provide the purpose for learning; situations vary between those of relevance to students' daily lives and concerns, and wider social issues of concern to societies generally; physics represented as a social practice, physics knowledge as a social construction that is open to change and influenced by social, political, historical and cultural factors; and the values implicit in physics practices and knowledge are matters for examination (Murphy and Whitelegg, 2006 p.19). This then places the social context as the driver of the subject knowledge for learning. Clearly such an approach would challenge most conventional curriculum and teaching programs in tertiary education; however there is enough evidence from other curriculum areas to suggest that these approaches are worth pursuing in ICT education to attract more students, and particularly more women. Context curricula are also essential in the challenge to break down the rusted stereotype of ICT employees as 'geeks in front of the computer all day'. The educational research and debates surrounding the importance of context curricula in reviewing and reforming threatened curriculum areas such as ICT also connect to the criticisms from employers in the ICT industry. Spencer (2003) challenged all involved in ICT education in Australian universities to address the narrow focus of the ICT curriculum, and claimed that few Australian degree programs reflected current ICT applications in business and the workforce and "this marginalises the users of Information Technology" (Spencer 2003 p.65; Spencer 2003 p.65). Spencer suggests we need to reconstruct the domain of ICT as a first step to equalising the gender imbalance and grounding the problem solidly within the discipline (Spencer 2003).

We are hypothesising that this cluster of different student experiences and confidence in programming, masculinised learning environment, content-driven abstract curriculum, and limited understanding of effective pedagogies all have connections to one of the hidden educational phenomena underpinning this cluster: the gendered attribution of success and failure. We consider that these threads of poor pedagogy in higher education contribute to the pattern of women and men undergraduates often experiencing curriculum, teaching and assessment systems differently and have outcomes that are as yet under-researched in ICT teaching and learning contexts. We will trace these theoretical connections in the following discussion.

DISCUSSION

The gendered attribution of success and failure needs some explanation first. There have been many studies in the last twenty years reported in educational and psychological literature on the gendered nature of psychological factors *other* than ability that affect success in cognitive tasks. During the 1980's, when gender related differences in abilities had been discredited as being insignificant as an explanation for the absence of women from many disciplines, both educational and psychological researchers started to explore the possibility that women and men tended to use their abilities in different ways (Head 1996). This led to the focus on cognitive style as a frame for analysing gender differences. The important characteristics of cognitive style are that the scale is bipolar and people are located on a continuum according to their preference between two contrasting ways of working (Head 1996). Here the *context* is very important as the advantage of any particular style is only conferred by context and not any measured level as would be the case on a uni-polar scale of ability. As Head (1996) describes, cognitive styles 'are all concerned with how individuals organise their environment and develop reasonably consistent strategies in dealing with unfamiliar tasks' (p.60). Whilst there are many styles described in the literature, one of the important clusters important in the context of this research is described as the attribution of success or failure or the 'locus of control'.

As Head (1996) describes, males tend to develop a defence mechanism of attributing success to their own efforts (internal locus of control) and failure to external factors (external locus of control). Girls however show the opposite and attribute failure to their own internal factors and success to external factors. For example a boy will attribute failure to 'too much sport', 'not enough study', 'hopeless teaching' or 'got sick' whereas a girl will blame herself 'for not studying enough' or 'not good at maths'. Girls on the other hand will externalise success as due to 'luck in studying the right questions', 'great teacher', 'friends helped me' while boys will internalise success as being smart, able and capable. Of course not all boys and all girls behave in these ways all the time but these gender patterns are well understood from the social and anecdotal to educational research (Head 1996).

We consider here that the educational implications of these findings have been under-theorised and under-utilised when understanding gender differences in success and failure attribution *as well as* in the gendered construction of unequal outcomes from education. There are learnings and implications from this research for the way that faculties organise curriculum, teaching and assessment systems as well as student course and career choice and even their motivation and interest in studying ICT. Twenty years ago, Dweck reviewed the socio-cognitive approaches to the study of motivational processes and how they affect success on cognitive tasks (Dweck 1986). She concluded that there was an educationally sound and replicable body of findings that 'highlighting performance goals relative to learning goals can have negative motivational impacts on achievement' (Dweck 1986). A focus on performance judgements can result in 'a tendency to avoid and withdraw from a challenge', whereas a focus on learning goals and effort creates a tendency to 'seek and be energised by challenge' (Dweck 1986). This is a powerful pedagogical argument for formative and continuous assessment as apposed to the summative exam-based approach that our assessment audit found does indeed undermine student achievement.

Bandura (1997) also observed different attitudes to learning and experiences in education due to gendered self-efficacy beliefs. According to Bandura, boys tend to overestimate their ability in a task, and when things do not go as well as anticipated, often blame an external factor. Girls on the other hand tend to underestimate their abilities and blame themselves first before any external factor

(Bandura 1997; Pajares 2002). The classroom implications of these gender differences is that girls may sink into a state of 'learned helplessness' where the perception of 'personal failure inhibits subsequent performance'. This also explains the other well known contemporary pattern of girls having to be 'super' high achievers to even contemplate pursuing studies in the physical and technical science subjects and their documented fragility in maintaining their self efficacy in these curriculum areas (Murphy and Whitelegg 2006) An 80% result on a maths test can trigger some young women to question whether they 'are good enough' to continue with maths at secondary school. It also assists in understanding the pattern of girls choosing to study science and technology subjects in higher numbers in single-sex secondary schools when compared with their co-educational sisters. Here they experience less disruptive classes and have a less stereotyped view of these subjects being masculine in their rarefied single sex atmosphere. The current numbers crisis in higher education is perpetuating many aspects of the 'single sex school for boys' and we are hypothesising that this produces a more fragile learning environment for women where self-efficacy at university may be fragile in the masculinised classroom alongside the abstract content-driven curriculum.

The corollary challenge for boys is learning to accept responsibility for their poor work (Dweck 1986, Head 1996). It should be noted that this gender difference is independent of ability. Girls proneness to internal distress underpins the theoretical reasons why girls do not pursue ICT study in secondary and tertiary education and have different experiences when they do. Girls who are doing well in performance terms are still vulnerable to evaluating themselves negatively and experiencing 'internal distress'.

CONCLUSIONS AND RECOMMENDATIONS

The WIT-S project recommendations are multi-layered in response to these gender based research findings and the wider research in post secondary ICT participation. The student-focused layer of recommendations is directed at recruitment, retention and advancement strategies for women students and have been well established for 2006/7 with the Women in IT @ Swinburne network. The 'Women in IT' network set up this year at Swinburne has been very successful already in providing learning and social networks for many students. This is a well-documented and successful strategy used around the world, including at Carnegie Mellon University, but will require ongoing University support to underpin the student energy and involvement (Margolis and Fisher 2002). This network becomes an umbrella for careers events, mentoring activities, role models from industry and networking with the wider networks of ICT women. New students in the faculty in 2007 are being offered a series of research and information sessions to support women in understanding, contesting and transforming these identities. This innovative strategy is based on earlier research that showed how educators could assist young people to understand and transform the gender discourses prevalent in their peer group (Connell 2002). Our goal is to raise awareness as well as shift behaviour in relation to both self and others when students attribute success and failure in their course.

The faculty-focused layer is directed at a range of professional and curriculum development strategies that will develop research material and professional development units that describe more fully the threshold knowledge to support a gender inclusive pedagogy in the Faculty. These research files would cover the gender research areas discussed in this paper; attribution of success and failure, cognitive style, single-sex secondary schooling and implications for Faculty learning environments, performance centred vs. learning centred assessment. These will require significant

leadership and resources to implement. If we were to take the research findings seriously then the faculty would be pedagogically different with a range of policies as guidelines for context and learning centred courses and sequencing. The other half of the Cohoon and Aspray (2006) 'things we know' (p.171) list focused on factors connected to faculty interventions that have informed our project initiatives also:

When faculty mentor for diversity (this action equalises the retention of undergraduate men and women)
Encouragement from faculty helps to equalise undergraduate retention
Same sex peers help to equalise undergraduate retention
Paired programming improves overall student retention.

Our findings reported here are consistent with other studies both in Australia and internationally. However, we also 'wonder' as well as theorise about the educational dissociation where the pedagogical implications of these findings are consistently ignored in practice. If half of our young women come from overseas, are at an age when they are vulnerable to evaluating themselves negatively even when they are high achievers, have less background experience of computers and less computer confidence, learn better in a learning-centred rather than performance-centred classroom, prefer the socio-technical contextual curriculum over the abstract, then why are they pedagogically invisible? It would appear that the very organisational processes that render women's knowledge as less status than men's are not even recognised as being gendered processes (Acker 1990). Acker would say these gendered discourses are mobilised at various decision–making sites within Faculty and University life and thereby become part of the educational policies and practices that enshrine this invisibility (Acker 1990). The valuing of masculine standpoints and experiences over the feminine is the basic conclusion in male dominated sectors of our society. Are there similar processes at work in densely masculine institutions such as ICT faculties where the educational needs of women in faculties are given scant attention? One important reason may stem from the frequent separation between educational and gender researchers, and ICT curriculum developers and educators. However, as we outline in this paper, there have been consistent gender research findings relating to the experiences of young women in ICT education for over twenty years, and yet these findings are consistently ignored in the curriculum and teaching development in ICT faculties. Perhaps in this current climate of haemorrhaging enrolments, both male and female, a greater degree of professional review or internal 'naval-gazing' is needed in ICT faculties to ensure they remain relevant to students in the twenty-first century.

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