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Enabling and Encouraging Greater Diversity in ICT

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Abstract

There is now a far greater level of heterogeneity in the university cohort in age, experience and cultural and socio-economic backgrounds than in the past. This means that assumptions about the equality of student knowledge and ability that may still exist could be causing difficulties for female and male students who are not school leavers or native English speakers. The issues faced by mature-age, international, and low socio-economic background female and male students are diverse and the potential strategies to assist in retaining current students and attracting future students are varied. Therefore, the strategies employed must address as many of these issues as possible in a comprehensive approach. The strategies suggested in the program proposed here are expected to achieve this end by providing multiple pathways in the first year of an ICT degree to address varying levels of experience and knowledge. This will be combined with social activities and a hub for student services provided by an ICT club intended to be a friendly and welcoming space for minority students whether that is by gender and/or cultural, language or economic background.

Keywords

Diversity, gender, ICT.

INTRODUCTION

If attracting and retaining a diverse cohort is to become a central tenet of information and communication technology (ICT) higher education, it must first be acknowledged that universities are no longer filled with traditional students straight out of high school (Bradley et al., 2008). Universities now attract both larger numbers of international students, but also larger numbers of mature-age students whether they are in their twenties, or have been in the workforce for some time and are returning to enhance their education or take a new path in their careers. This heterogeneity in the university cohort, in age, experience (Cartney & Rouse, 2006; Herzog, 2005) and possibly English-language proficiency, means that the expectations about the equality of student knowledge and ability that may still exist could be causing difficulties for students who are not school leavers or native English speakers. These problems can be at opposite ends of the spectrum: some mature-age students who have been working in ICT for years may have far greater knowledge and skill-sets than most of the cohort; or they may have no experience at all and be absolute beginners. This can also be true for some high school leavers and some international students, both of whom may also have English-language proficiency issues (Beasley & Pearson, 1999; Bonanno, 2002). Two strategies will be suggested here that would go some way to support the current level of diversity while also accommodating even greater diversity in the future: the introduction of a multiple-pathways course in the first year of an ICT degree (Alvarado et al., 2012; Powell, 2008; Roberts et al., 2011a); and the establishment of an ICT club, a concept formulated from a literature review which revealed the success of a program of outreach to high schools (Lang et al., 2010), the creation of a women's network (Lewis et al., 2007) and the establishment of a women's advisory council (Margolis & Fisher, 2002).

The strategy that would offer a solution to the range of student's prior experience and knowledge would be the provision of a first year course that recognises this and allows students to enter a version of the course that best suits their skill and knowledge level (Alvarado et al., 2012; Powell, 2008; Roberts, et al., 2011a). This multiple-pathways course would allow female and male students to participate in a class of students of equal or similar ability and understanding and to build up their knowledge at a suitable pace. To achieve this parity amongst students who differ in age, knowledge and experience would require an assessment to be conducted prior to the

beginning of the university year. This would facilitate the splitting of the first year's ICT cohort into classes based on an evaluation of each student's knowledge and ability. Although there is opposition to the streaming of primary and secondary school students (Zevenbergen, 2002) this is an approach that allows students with equal skills to learn at a pace that suits them rather than find that the assumptions about their prior knowledge disadvantages them from the start. This approach was successfully implemented at Harvey Mudd College (Alvarado et al., 2012) where the Body of Knowledge to be imparted to students was the same, but the manner in which it is taught to each class differed to suit the level of knowledge and experience held by the class members. Greater consideration should also be given to the use of English as the means by which information is disseminated to students so that turns of phrase and slang shared by English-speaking students are removed to reduce the learning burden on international and domestic female and male students whose first language is not English (Andrade, 2006; Bretag et al., 2002). At the end of their first year, all students should have a grasp of the foundational principles and be ready to take courses in the area of ICT they want to pursue.

The strategy that would enable and encourage greater gender diversity in the student cohort would be the creation of a women-friendly ICT club which would be modelled, in part, on the successful program established at Carnegie Mellon University. That program began by educating high school computer teachers, and changing the entry requirements for aspiring students (Blum & Cortina, 2007; Margolis & Fisher, 2002). The program proposed here would go further than that by combining the multi-pathway strategy (Powell, 2008; Roberts et al., 2011b) based on identifying each student's prior knowledge of ICT and identifying assumptions in the curriculum which might disadvantage them (Roberts et al., 2012) with the women-friendly ICT club strategy. Although the club would be at the heart of the program, it would not necessarily be exclusive to either women or university students as its events could be used to attract potential students from local primary and high schools. To ensure the club remains female-friendly, however, all decision-making positions would be the domain of the female members. The club's primary functions would be directed by the club members to ensure it provides opportunities for current female students, both domestic and international, to socialise and to get extra help if they are struggling with difficult parts of their courses. Rather than identifying at risk students and applying assistance to them individually, the club would be a hub for these services which would be made available to all the members on a regular basis. As an example, one weekly event could be a conversational gathering of international and domestic students to discuss what they are learning in their classes. This would be beneficial in several ways: students from a Non-English speaking background could practice their language skills; the international and domestic students could become more familiar with each other, thus enhancing their social integration; and all the students could benefit from the opportunity to discuss any difficulties they may be having.

PROPOSED PROGRAM

The two-pronged program presented here is the product of research on attrition in ICT degrees in Australia which identified significant factors contributing to attrition from ICT degrees. Through a process of identifying strategies for reducing attrition suggested by the literature, and in surveys completed by members of the Australian Council of Deans of ICT (ACDICT) and the Australian Computer Society (ACS) (Ogunbona et al., 2013), and mapping those strategies to the significant factors contributing to attrition from ICT degrees, it has been recognised that these strategies could be more effective if they were combined to form a comprehensive program dedicated to outreach, assistance, support and encouragement of students, as later discussion in this paper will demonstrate.

It is not feasible to present all the research done to reach this conclusion, but the following tables present the core findings of: a survey of students who had left their ICT degree (Roberts et al., 2011a; Roberts et al., 2012) from which 26 factors were identified as significant contributors to attrition (Table 1); a literature review (Table 2) of strategies that have been employed to reduce attrition; and surveys of members of ACDICT (Table 3) and the ACS (Table 4) (Ogunbona et al., 2013) regarding the potential strategies that have or could be used to increase the level of student gender diversity in the ICT degree cohort as the lack of female ICT students continues to be a concern around the western industrialised world (Boivie, 2010; Katz et al., 2006; Lewis et al., 2007; Margolis & Fisher, 2002).

The factors identified as contributing to attrition of ICT students (Roberts et al., 2011a; Roberts et al., 2012) are presented in Table 1 in order from the highest level of agreement: "No or few females in class" (75.4% agreement) to "Course too mathematical" which received a ranking on the cut off point of 33.3% agreement. This cut off point was established in the research as a reasonable level of agreement with the statements presented in the survey. Where enough participants had chosen *agree* or *strongly agree* for a statement to reach 33.3%, it was identified as a contributory factor.

Table 1. Factors identified as contributing to attrition of ICT students (Roberts et al., 2011a; Roberts et al., 2012)

Contributory Factors in Ranked Order
No or few females in class
Didn't enjoy classes
Picked wrong degree
Course expectations unmet
Boring classes
Didn't feel I fit in or belong
Didn't understand concepts
Course lacked workplace focus
Teaching pace too fast
Teachers didn't explain exercises
Results not as expected
Academic environment unsuitable
Course lacked practical applications
Course lacked business focus
Too many distractions
I lacked expected knowledge
Didn't make friends
Course too theoretical
University too expensive
In minority in class
Couldn't get help
Didn't understand terms
Conflict with work
Timetable clash with work
Not encouraged by teachers
Course too mathematical

Table 2 presents the strategies identified in a literature review which revealed that, despite there being decades of research conducted on attrition to determine its causes, much less work has been devoted to finding appropriate and effective means to combat it.

Student mentoring by an adult was advocated by Muller (1997) who saw it as a way to retain female students in engineering and related sciences. Muller's (1997) scheme, called MentorNet, involved the mentoring of female students via email by females working in industry and was based on the success of four previous programs, three of which specifically targeted female students. According to Muller (1997) there are six benefits of "e-mentoring" for female students. These are having someone who can provide guidance and advice based on their experience while supporting and encouraging their mentee and providing them with access to professional networks. The last, but likely to be most important benefit, is the insight the mentor can provide to help "decode" the cultural and structural elements of their field which may not be as readily understood by a female student. McInnis et al. (2000a) believed mentoring would be beneficial for all students and cite four functions of a mentor-mentee relationship: emotional and psychological support; direct assistance with career and professional development; and role modelling. Both Muller (1997) and McInnis et al. (2000a) wrote explicitly

about adult mentoring of students whereas Connolly and Murphy (2005) suggest that identifying appropriate peer mentors can also ease the transition for new students, giving them a friendly face with which to identify, and a person with whom to speak about concerns, who is not part of the institution but can provide them with insider knowledge.

Table 2. Strategies suggested by the literature to attract and retain students

Suggested strategy	Author(s) & Year
Female industry mentor for female students	Muller (1997)
Male industry mentor	McInnis et al. (2000a)
Peer mentor	Connolly & Murphy (2005)
Small group learning	Cartney & Rouse (2006)
Relationship building with cohort by administrators	Brier et al. (2008)
Foster student socialisation	Bruning (2002)
Modify ICT prerequisites	Margolis & Fisher (2002)
Broaden admissions	Margolis & Fisher (2002)
Connect with high schools	Margolis & Fisher (2002)
Identify high-risk courses	Blanc et al. (1983)
Monitor 'at risk' students	Rickinson & Rutherford (1996)
Recognise educational differences	Powell (2008)

Peers can also be helpful in small group learning which will foster student potential and promote integration, progression and retention (Cartney & Rouse, 2006). This is supported by studies that indicate that students identify social contact as a valuable component of their learning experience (Longhurst, 1999; Sander et al., 2000), so opportunities for collaboration in small groups may counteract the otherwise fragmented experience many non-traditional and mature-age students have of university life, whilst imparting valuable skills which traditional students can take into the workplace.

Brier et al. (2008) believe that the university needs to demonstrate commitment and investment in student well-being and persistence and, to that end, they established the Strategic Retention Initiative which personalises the institution's administration, fosters institutional affiliation, identifies problems or potential problems, and eases the student's transition to the university by promoting academic and social integration. Bruning (2002) also advocates the establishment of a relationship between the university and its students because effectively managed relationships between an organisation and its public affect key public member attitudes, evaluations, and behaviours. Bruning's (2002) research demonstrated that a satisfactory relationship with their university differentiated those students who returned to the university from those who did not.

However, Connolly and Murphy (2005) view a combination of approaches as being much more effective in increasing retention than single strategies. They suggest that combined initiatives such as being welcoming to students, running small group tutorials, using innovative teaching, and establishing learning support centres are all advantageous in increasing retention rates by fostering student socialisation in their new environment.

Margolis and Fisher (2002) did not view teaching practices within the School of Computer Science at Carnegie Mellon University as problematic but saw a need to broaden the admission criteria to the school by removing the candidate prerequisite of having computing experience, and the need to make a concerted outreach effort to high school computer teachers. Margolis and Fisher (2002) conducted interviews with both highly experienced and very inexperienced computer users and concluded that "women who are complete novices are no less likely to persist than the most experienced women. Their stories show us that prior computer experience does not make the critical difference" (Margolis & Fisher, 2002, p96). Their finding resulted in a change to the admissions policy which removed the experience prerequisite and broadened the personal characteristics of those it accepted by recognising that leadership and a willingness to contribute to their community were just as admirable as excellent scholastic results.

Additionally, Margolis and Fisher (2002) championed the outreach effort to high school computer teachers who were invited to participate in the Carnegie Mellon Summer School. This created the opportunity, not only to improve the teacher's programming knowledge, but also to make them more acutely aware of their own

teaching practices and attitudes and the environment they were creating in their own classrooms. The teachers were then able to recognise that they sometimes allowed the boys in their classes to dominate and that female students were often given the task of note-taking or assigned some other passive role, rather than being given an equal opportunity to participate fully in the computing exercises. Their ability to see this as a failing allowed the computer teachers to return to their classrooms armed with the willingness to ensure greater equality in the treatment of their students.

Quite a radical position was taken by Blanc et al. (1983) when it came to addressing student learning issues when they instigated the Supplemental Instruction (SI) program, which identified high-risk courses, rather than high-risk students, and attached the services provided by the university directly to each difficult course, rather than individual students. The authors (Blanc et al., 1983) defined a high-risk course as one commonly regarded as a difficult, entry-level course in which student failure rates and withdrawals exceed 30 percent of course enrollees. Their solution centred on not only reducing the withdrawal rate but also in identifying what elements of the course made it difficult. Their method for delivering this solution was to involve a specialist who attended lectures, took notes and participated as “a student of the subject” (Blanc et al., 1983, p81). By integrating, just as a student would, the specialist gained direct experience of the course and could act as a model of how to think and talk about the content, and demonstrate how to be proficient in the course, when they ran supplementary tutorials for struggling students. Almost twenty years later in Australia, McInnis et al. (2000a) also advocated SI as a solution for student attrition in their report on non-completion in the university education sector.

Rickinson and Rutherford (1996) also believed that the combination of a number of factors could create the very conditions for students at risk of withdrawal that would lead them to quit. They advocated the systematic monitoring of students who find the academic and social demands of university life trying. By monitoring these students the system could provide: early identification of students in difficulty; evidence of course structure issues; and a greater insight into the admissions process, all of which had the potential to be addressed or modified, thereby reducing the anxiety and stress experienced by underprepared students entering the university system and allowing them a greater opportunity to succeed.

Another way to support entering students is by recognising their educational differences, as the time when most students enrolled directly after finishing high school has passed. The difficulties many students experience when they find that they are not equipped with the prerequisite knowledge some courses assume they have, simply adds to the burden of acclimatising to the university environment. Providing multiple pathways into computing studies has been suggested (Powell, 2008; Roberts et al., 2011a; Roberts et al., 2012) as a means to remove an unnecessary impediment to the progress of those who do not have the expected background and skills structured into existing courses. By separating students with less prior knowledge into classes that allow them to reach the requisite level, while not holding back those with greater experience and skills, is one way to better serve students and, thus, reduce the attrition resulting from students falling behind.

Although the focus of the research by the various authors in Table 2 was primarily on retaining students enrolled in ICT degrees, much of that work investigated and discussed the lack of females enrolling and remaining in those degrees. While some consideration was given to students from socio-economic groups that are currently under-represented in the ICT degree cohort, this was not the main focus. Nevertheless, it is possible to claim that a range of efforts, such as those suggested in the literature in Table 2, combined with strategies suggested by the members of ACDICT and the ACS, would be effective in attracting a wider diversity of students while also assisting in the retention of a greater number of ICT students.

As can be seen in Tables 3 and 4, both the members of ACDICT (Table 3) and ACS (Table 4) had, in some cases, similar ideas to each other and to the literature. All three sources suggested role models/mentors while the members of ACDICT and ACS believed students should be given concrete examples of the types of careers that will be open to them, once they graduate. While some of the literature emphasised the need to foster social integration amongst all students, both the ACDICT and ACS members suggested ways to assist female students to work together and help themselves through networking, being members of a club and attending events specifically intended for them. The numbers in Tables 3 and 4 indicate how many respondents suggested each strategy. There were 46 respondents to the ACDICT survey and 132 respondents to the ACS survey. It must be noted, however, that respondents did not necessarily provide answers to every question presented.

Although the literature review included researchers who identified a range of issues contributing to the negative experiences female students might have while undertaking an ICT degree, the members of ACDICT did not suggest any strategies that might explicitly address concerns such as the negative behaviour or attitude of their peers or teachers. In contrast, those who were working in the ICT industry mentioned strategies to deal with these concerns most frequently in their responses (see Table 4). Although the ACDICT members were asked explicitly to write about strategies currently being used or strategies they believed could be put in place, the members of ACS offered their ideas on strategies that would help as part of their response to questions about

public perceptions of ICT as a profession and perceptions held by future students about ICT degrees. The members of ACS suggested that existing ICT courses may not be adequate to meet the needs and interests of minority students, and that some effort should be expended on changing what they saw as negative perceptions of the industry as portrayed by the media. Both ACDICT and ACS members suggested what might be seen as quite radical ideas about how to attract more female students. ACDICT members suggested offering financial incentives or financial assistance to potential female students while one ACS member suggested giving first priority of entrance to an ICT degree to them.

Table 3. Strategies suggested most frequently by members of ACDICT to attract and retain students

Suggested strategy	No.
Emphasise future careers for female students	7
Provide role models/mentors for female students	6
Run camps or enrichment programs for high school students	6
Establish women-specific clubs	6
Run women-specific events	6
Offer financial incentives/assistance to female students	4

Table 4. Strategies suggested most frequently by members of ACS to attract and retain students

Suggested strategy	No.
Encourage awareness of/change negative behaviour/attitudes of male students and academics and equip students with necessary skills	9
Provide examples to female students of real-world benefits and careers provided by ICTs	4
Provide role models/mentors to female students	3
Offer new or modify existing courses to attract female students	2
Establish a women's network	1
Give first priority to women entrants	1
Promote a positive view of ICT via the popular media	1

No matter what other strategies are put in place, improving the teaching and learning experience for all students is vital (Pascarella et al., 2011). Ensuring that all academic staff teaching computing subjects are made aware of both the assumptions about student's prior knowledge and experience that may be intrinsic to the course, as well as their own possible negative practices and biases, will assist in this process. One example of the possible assumptions made about prior knowledge and experience of students is the expectation that each one has already had some experience with computers and programming before they begin their degree (Alvarado & Dodds, 2010; Barker et al., 2009). Identifying and addressing these issues will go some way to reducing the number of difficulties students encounter, even before any other strategies are introduced.

It is not feasible or desirable to make use of every strategy identified as this would be burdensome to universities. There were two strategies that emerged from the literature review, however, that could address the most pressing issues for a diverse student cohort and those are the ones discussed here. The multiple-pathways strategy could assist an entering cohort that is diverse in age and experience and the women-friendly ICT club could also contribute to the learning outcomes for first year students by connecting them to their peers who are further advanced in their ICT degrees. The social and academic integration of students is commonly cited (Barker et al., 2009; Braxton et al., 1997; Hillman, 2005; Tinto, 1975) as a means by which to retain first year students who are at most risk of attrition (Hermanowicz, 2006; Hillman, 2005; Milem & Berger, 1997). As with the Women@SCS club (Frieze et al., 2006), it is likely that a female-friendly club would also attract male students and this, in turn, would create a noticeably better and more supportive environment for all members as it did in the School of Computer Science at Carnegie Mellon University (Frieze et al., 2006). If this change was replicated in Australian ICT degrees, it might be expected that this more balanced view would be taken by those students into their workplaces, thus reducing the concern cited most frequently by members of the ACS.

A successful club would also encompass many of the strategies suggested in the literature (Table 2) and by members of ACDICT (Table 3) and the ACS (Table 4), by offering opportunities to *network*, *learn about future careers*, and *hear from and talk to successful people*. These kinds of opportunities would assist in reducing some of the stress caused for young women in *being a minority* (Table 1), while *creating a more collegial atmosphere for all students*. It is also likely that some of these students would become future success stories and *mentors* for those who follow them (Frieze & Blum, 2002). One of the ways to achieve this would be through a form of mentoring as this was a strategy suggested by the ACDICT and ACS survey respondents as well as the literature (Connolly & Murphy, 2005; McInnis et al., 2000a; Muller, 1997). Providing a way to assist students in a non-intrusive manner by creating a personal connection to students in their second and third year of an ICT degree, or an academic or an industry member, would allow students to be more forthcoming in conversation and facilitate discussion of their problems and concerns which might otherwise remain hidden. One of the regular activities of the club could be alternate lunch or dinner networking events where mentors and mentees could meet to discuss the concerns and difficulties the students have and to identify solutions. There will, however, still be students who are struggling. Those students should be identified early – not after their first major exams (Rickinson & Rutherford, 1996) – and given all possible assistance through the club’s connection to the services provided by the university. Just as importantly as the assistance given, there must be a system to track each identified student so that it is possible to know whether the mentor and the assistance given has had the desired outcome and ensure alternative solutions are offered.

Not only would the club serve the interests of currently enrolled students, it could also be the hub of a variety of *outreach activities* (Table 3) to spark interest in primary school students and attract and encourage enrolments by high school students. These activities would involve current university students who would be *role models* (Tables 3 and 4) for the younger students while also creating a welcoming and exciting experience to enthuse students about ICT and its many applications in real-world scenarios. There would also be outreach to teachers and parents to ensure they were fully informed about the future careers of students who have graduated with an ICT degree. The following diagram (Figure 1) depicts how the club could become the heart of the outreach effort, both within the university to attract students from other faculties to take complimentary computing courses, as well as external outreach to schools.

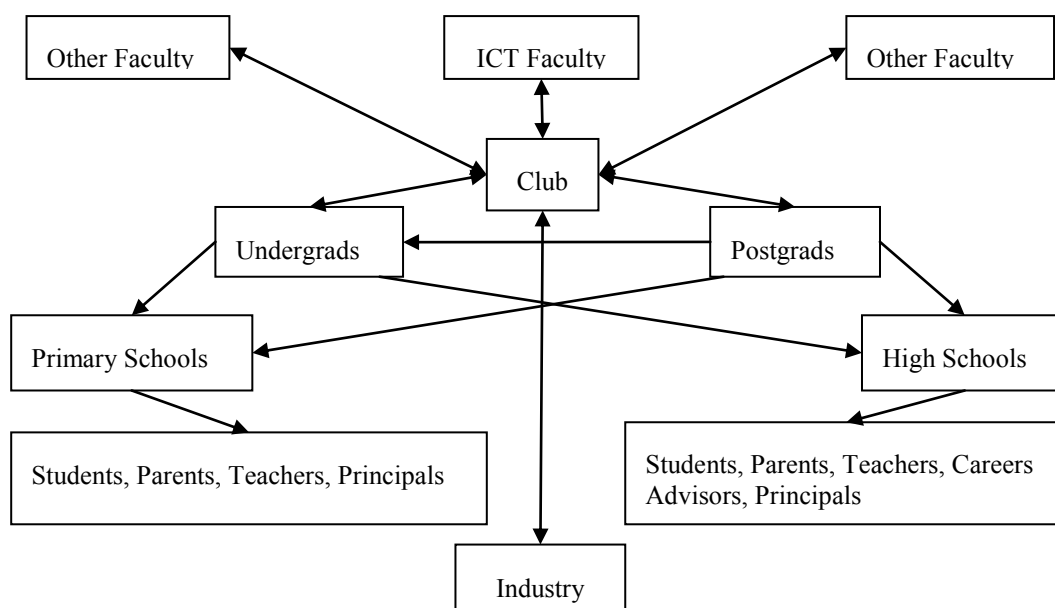


Figure 1 ICT Club diagram depicting outreach and collaboration

The double-headed arrows in Figure 1 indicate outreach and collaboration with industry, undergraduate and postgraduate students and the faculties of the university. The single-headed arrows show outreach efforts and who is targeted. Undergraduate and postgraduate students would not only benefit from the club’s activities but would also be involved in the outreach efforts to primary and high school students, their teachers, careers advisors, principals and parents. Although the club’s central *raison d’etre* is to support all students while creating a positive and welcoming space for women, the diagram shows that it could become a powerful tool for inspiring, attracting and integrating all students as well as garnering assistance and input from industry.

CONCLUSION

Establishing a women-friendly club that serves the needs of all ICT students by bringing together activities and university services would improve their integration into the academic and social lives of their faculty. Combining the club activities and outreach to other faculties of the university as well as to local primary and high schools, with a redesigned first year course that takes their diversity of experience and knowledge into account, would prove attractive to students who might otherwise not have considered undertaking an ICT degree. Increasing the number of female students, as well as those from a variety of cultural and socio-economic backgrounds, would enhance the present level of gender diversity in ICT degrees and decrease their status as minority groups thus encouraging greater diversity in the future through the outreach efforts of the ICT club.

Of course there may be objections to the instigation of an intensely proactive program that requires considerable redesign of existing courses within the ICT degrees offered in Australian universities. It is also likely that there will be objections based on the need for some level of additional funding for this program to succeed (McInnis et al., 2000b). Designing a multi-pathway first year ICT course and establishing a viable women-friendly ICT club will take some time and effort by both academic and general staff members but it is reasonable to assert that if industry, government and higher education institutions are serious about increasing all types of diversity in ICT, then such measures should not only be considered, as McInnis et al. (2000b) suggested, but must actually be tried.

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