Abstract

Research has shown that females do not participate as much as males in Information Technology (IT) related studies in both Australian secondary and tertiary education. Despite research in the 1990s which identified such underrepresentation of girls in IT studies, the rate of female enrolment still remains consistently low. Drawing on relevant literature, this paper explores the possible key factors and statistical data which highlight the existence of gender disparity in IT studies. The statistical data regarding female enrolment in Australian secondary and tertiary IT education suggests a possible correlation between secondary IT and tertiary IT participation. In conjunction with these statistics as well as the wider literature, a range of possible key factors are outlined to explain the pattern of females’ underrepresentation in IT-related studies. The project also explores how the possible key factors in the low female participation rates in undergraduate Computer Science (CS) degrees occur in two different educational contexts, in Australia and Taiwan. The study adopts Eccles et al. Expectancy Value Model in exploring the psychological and social factors which influence female students’ CS enrolment decisions. A mixed methods approach is used to further triangulate Eccles’ theory of social and psychological factors in influencing individuals’ course selections.

Situating the Problem

Currently there are limited numbers of females studying Information Technology (IT) related degrees in higher education in Australia. In 2004, only 20% of commencing tertiary computing students were female (DEST, 2005, as cited in Craig, 2005), which suggests that the field of computing is still dominated by males. It is proposed that an understanding of the possible key factors which account for females’ non-participation in IT-related degrees can assist in understanding their non-participation in Computer Science (CS) degrees. This paper commences with an insight into current female participation in IT studies in Australian secondary and tertiary education, followed by an outline of possible key factors in females’ lack of participation in IT and CS related degrees. This paper introduces an on-going doctoral project which explores the factors that influence females’ participation in CS degrees in two different educational contexts, Australia and Taiwan. The doctoral research adopts Eccles et al. (1983) Expectancy Value Model to explore the possible range of social, psychological and motivational factors in determining participants’ ultimate course selections in Australia and Taiwan.
**Theorising the Problem**

**Eccles et al. Expectancy Value Model**

Eccles et al. (1983) Expectancy Value Model is adopted for this research to explore the psychological and social factors which influence course enrolment decisions made by males and females. Eccles (2005) states that educational and occupational choices are guided by: a) expectations for success on the various options, as well as one’s sense of competence for various tasks; b) the relation of the options to one’s short and long range goals, core personal and social identities, and basic psychological needs; c) the individual’s culturally based role schemas, such as those linked to gender, social class, religious group and ethnic group; and d) the potential cost of investing time in one activity rather than another. These factors will be further explored in the questionnaires and the interviews to be undertaken later in this research to enable an exploration of the ethnic and gender differences in tertiary CS courses in two countries and enable the validity of the hypothesis of females being less confident than males about their skills and potential in CS due to stereotypes, perceptions and parental influences to be explored.

**Females in Computer Science**

The recent skills shortage in the Australian IT industry was identified in a longitudinal study titled WinIT (von Hellens & Nielsen, 2001). Approximately 40% of all female students studying in IT education in Australia were from Asian backgrounds (von Hellens & Nielsen, 2001). This study suggests cultural factors as one of the major factors that influence females’ decision on whether to enter the IT industry. Such finding has prompted the current research to explore the possible key reasons for female students’ CS participation in two different educational contexts. Since in many studies the ways to improve the recruitment and retention of females in IT have been examined (Woszczynski et al., 2006), in this research females’ participation in CS will be examined, as there appears to be limited current research on females’ participation in CS in both Australia and Taiwan.

**CS curriculum in Australia and Taiwan**

A comparison of the CS undergraduate curriculum structures at Monash University (MU) and National Taiwan University (NTU) revealed a lot of similarities. For example, during the first year of the CS studies, both universities require students who study CS to study programming and mathematics, such as Mathematics for computer science I and II at MU, and NTU requires students to study Calculus A I and II. In the second year, both institutions require students to study algorithms and data structures. From the third year onwards, both institutions begin to place more emphasis on the aspect of design, such as Analysis and design of algorithms at MU, and Digital system design and Compiler design at NTU. Despite such similarities, a notable difference is noted, as the curriculum guide outlined by NTU does not indicate the choice of electives. In contrast, MU students have the choice of two electives per year. It can also be noted that MU students begin a project in their third year while NTU students only commence Special projects I and II in their fourth year. Overall, there are some similarities in the CS course requirements at both MU and NTU. Although the titles of the units at these institutions are not identical, the curriculum content of both institutions demonstrates similar sets of skills and knowledge that students must learn in CS courses.
Recent Scenario

Females in secondary IT education

Millar and Jagger (2001) reported a decline in female computing graduates in the UK, USA, Canada, Taiwan, Spain and Ireland. This decline in computing graduates suggests that there may be a decline in the number of females studying IT subjects at high schools. For example, Victoria experiences a decline in female participation in secondary final year IT subjects, IT Applications and Software Development (Victorian Curriculum and Assessment Authority, 2009), which might result in corresponding low figures in undergraduate studies (see Table 1). This issue will be discussed later in the paper.

<table>
<thead>
<tr>
<th>Year</th>
<th>IT Applications Males</th>
<th>IT Applications Females</th>
<th>Software Development Males</th>
<th>Software Development Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students enrolled</td>
<td>Enrolment decline %</td>
<td>Students enrolled</td>
<td>Enrolment decline %</td>
</tr>
<tr>
<td>2004</td>
<td>5189</td>
<td>26%</td>
<td>2503</td>
<td>30%</td>
</tr>
<tr>
<td>2005</td>
<td>4478</td>
<td>23%</td>
<td>1976</td>
<td>24%</td>
</tr>
<tr>
<td>2006</td>
<td>3749</td>
<td>19%</td>
<td>1534</td>
<td>19%</td>
</tr>
<tr>
<td>2007</td>
<td>3444</td>
<td>17%</td>
<td>1194</td>
<td>14%</td>
</tr>
<tr>
<td>2008</td>
<td>2997</td>
<td>15%</td>
<td>1066</td>
<td>13%</td>
</tr>
</tbody>
</table>

Table 1 shows the male and female enrolment numbers and enrolment percentage decline in IT Applications and Software Development. A steady enrolment decline is shown in the number of students enrolled in IT Applications, as 2503 females were enrolled in 2004 and the enrolment continued to decline in the next four years to just 1066 in 2008. Female enrolment in Software Development also experienced a significant decline, decreasing from 185 students in 2004 to just 93 in 2008. Software Development highlights a significant difference in gendered participation, with 2313 males studying the subject compared to just 185 female students in 2004. IT Applications experienced a certain percentage decline in enrolment, with a 3% decrease in male enrolment from 26% in 2004 to 23% in 2005, while female enrolment rate declined from 30% in 2004 to 24% in 2005. Male enrolment decline in Software Engineering shows a sharper 6% decrease from 27% in 2004 to 21% in 2006. Overall, the number of enrolment of males and females, as well as the decline of both male and female enrolment, suggests that there is a strong male domination in both subjects, and there are still far more males than females studying both subjects.

Females in tertiary IT education

There is also a decline in the number of Australian females undertaking IT-related degrees over the past few years. The aggregate proportion of females enrolling as new undergraduate IT students in Australian universities has declined from 26% in 2001 to 20% in 2005 (Department of Education Employment and Workplace Relations, 2006). For example, Monash University has experienced a steady decline in the number of females enrolling in undergraduate IT degrees, including the Bachelor of Information Technology and Systems (BITS), Bachelor of Business Information Systems (BBIS),
Bachelor of Software Engineering (BSE) and Bachelor of Computer Science (BCompSc) (Monash University, 2009). A decline in student enrolment in IT-related degrees at Monash is shown in Table 2:

Table 2. Student enrolment in IT-related degrees at Monash University, 2006-2008

<table>
<thead>
<tr>
<th></th>
<th>BITS Males</th>
<th>BITS Females</th>
<th>BBIS Males</th>
<th>BBIS Females</th>
<th>BSE Males</th>
<th>BSE Females</th>
<th>BCompSc Males</th>
<th>BCompSc Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>291</td>
<td>85</td>
<td>62</td>
<td>18</td>
<td>110</td>
<td>12</td>
<td>272</td>
<td>31</td>
</tr>
<tr>
<td>2007</td>
<td>497</td>
<td>119</td>
<td>127</td>
<td>30</td>
<td>97</td>
<td>7</td>
<td>237</td>
<td>24</td>
</tr>
<tr>
<td>2008</td>
<td>626</td>
<td>145</td>
<td>201</td>
<td>49</td>
<td>101</td>
<td>8</td>
<td>208</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 2 highlights that student enrolment in IT-related degrees varied each year during the 2006-2008 time span. The enrolment numbers show that there was a consistent increase in both male and female enrolment in BITS and BBIS over the three-year span, and a gradual decrease in both male and female enrolment in BCompSc. However, a high male-to-female ratio in all IT-related degrees is conspicuous (see Table 3):

Table 3. Male-to-female ratio in IT enrolment at Monash University, 2006-2008

<table>
<thead>
<tr>
<th></th>
<th>BITS Male to Female Ratio</th>
<th>BBIS Male to Female Ratio</th>
<th>BSE Male to Female Ratio</th>
<th>BCompSc Male to Female Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>3.42:1</td>
<td>3.44:1</td>
<td>9.17:1</td>
<td>8.77:1</td>
</tr>
<tr>
<td>2008</td>
<td>4.32:1</td>
<td>4.10:1</td>
<td>12.63:1</td>
<td>8.00:1</td>
</tr>
</tbody>
</table>

Table 3 illustrates a strong male-to-female ratio in all IT-related degrees, ranging from 3.42:1 to 4:32:1 in BITS and BBIS respectively, to 8:1 in BCompSc and 13.86:1 in BSE. There is a consistent increase in the male-to-female ratio in BITS, while BBIS experienced an increase in 2007, then a decrease in 2008. BCompSc has the second largest male-to-female ratio, ranging from 8:1 to 9.88:1. The male-to-female ratio of BSE also ranges from 9.17:1 to 13.86:1. Overall, this high male-to-female ratio clearly shows that there is an overwhelmingly larger cohort of males studying BSE. The low number of females enrolled in CS and the high male-to-female ratio in CS not only illustrate an ongoing concern for CS female participation in Australia, but also bring to light a range of factors which contribute toward this pattern, which is discussed in the following section that examines females’ participation in CS both in Australia and Taiwan.

**Females’ Underrepresentation in IT: Possible factors from the literature**

While a complex array of family factors, pedagogical factors, extracurricular factors and social factors interplay to explain youths’ interest and achievement toward science and technology (Larose et al., 2006), recent literature suggests that the possible key factors behind females’ underrepresentation in IT include self-efficacy, stereotypical image, single-sex setting, misconceptions of IT, influential factors for choosing CS, parental influence, classroom climate and the effect of sex-role (see Bandura, 1997; Timms et al. 2006; Craig, 2005; Papastergious, 2008; Messersmith, 2008).

Bandura (1997) states that self-efficacy beliefs constitute as predictors of individual academic performance. When the environment allows adolescents to strengthen beliefs in science and technology, they are more likely to maintain their interest in the field. However, if young females do not have strong self-beliefs in computing abilities in high schools, they are less likely to pursue IT-
Female contributing to the underrepresentation of female undergraduates in Computer Science in Australia

related degrees such as CS at university.

Studies suggest that stereotyped images and perceptions of IT may have also prevented some young females from entering the field of computing. Results from Timms et al.’s (2006) survey indicated that out of 1453 female respondents from Year 11 and Year 12, 91% were ‘non takers’ of IT subjects and only 9% were ‘takers’. These ‘non takers’ perceived advanced IT subjects as ‘boring’ and believed that computer uses lack social interaction.

It has also been suggested that the underrepresentation of females in computing is mostly due to their misconceptions of IT which caused their non-selections of IT subjects at high schools (Craig, 2006; Papastergiou, 2008). Females’ misconceptions of IT can influence non-selection of IT subjects at high schools. Papastergiou (2008) highlights that the misconceptions that young females possess when considering CS degrees such as: CS is ‘not for females’, CS is ‘only programming’, CS is ‘difficult’, CS careers ‘require long hours’ on the computer and consist of ‘little human interaction’. These misconceptions and inadequate knowledge regarding CS may have a great influence over females’ decisions in CS degree selections ultimately.

Additionally, females in single-sex secondary schools were found to have higher participation rates in computer activities and more positive attitudes toward the field in general (Craig, 2005). More than 90% of the female undergraduates studying IT-related studies at the University of Technology, Sydney, had attended single-sex secondary schools (Craig, 2005). Female undergraduates studying IT credited their participation in higher education IT due to greater access to computers at secondary schools, more female role models, high acceptance of computing as a female activity and school curriculum tailored specially for females.

Classroom climate is another important factor alongside parental influence in Wasburn and Miller (2004)’s study, which found that the following were observed in an undergraduate CS classroom: gender specific jobs were assigned to females, females’ discomfort about males’ attitudes, lack of teacher support, lack of role models, and difficulties in understanding course material. Female CS students also identified the challenge of having to keep up-to-date with new programs and technologies constantly (Miliszewska et al., 2006).

Apart from the factors which influence females’ CS course selections, studies also suggested that parental influence plays a key role in children’s early IT-related learning and how children value IT-related studies later on. Messersmith et al. (2008) suggest that many females who chose IT careers were heavily influenced by family factors, with parents giving them guidance on computer uses. Bandura (1997) believes that parents’ expectations of their children often differ by sex and also suggests that children were often influenced to choose professions as expected by their parents.

The influence of sex-role in CS course selection is possible as sex role typing and its accompanying stereotypes constitute different expectations for both sexes. Lemaku (1979) states that cultural sex role demands influence females’ choice of non-traditional and traditional careers. Cohoon (2002) also argues that as the society portrays an image of computing as a male activity, fewer females will be likely to consider CS unless they are encouraged to do so.

Nevertheless, misconceptions regarding IT can be addressed if influential factors for choosing CS are understood, as this encourages females to pursue studies in the field. Margolis and Fisher (2002) found that females enter IT fields because they are successful in mathematics and science, enjoy problem-solving and/or enjoy programming. CS students in a study by McInerney et al. (2006) indicated that an interest and a proficiency in programming were the primary motivations for choosing CS, as well as having studied advanced placement programming classes in high school.
Research Design of Current Study

The aim in this research project is to examine major factors which affect female students’ participation in CS degrees both from the literature and research data. This research project explores:

1. What are the factors which influence female undergraduates’ participation in CS degrees in Australia and Taiwan?
2. What were female students’ understandings and perceptions of CS as a study or a career prior to their enrolment in a CS degree?
3. What are the similarities and differences in the factors which affect female undergraduates’ participation in CS degrees in Australian and Taiwan?

These research questions form the basis of this research, the structure of the questionnaire and direct the flow of subsequent interviews.

This research project explores a range of possible factors which contribute toward females’ participation in CS degrees in Australia and Taiwan. This research is also currently exploring the possible value of researching both male and female students’ participation in CS, and is aware of the Australian context which has a high number of international students, which is likely to affect the outcome of this research. It should be emphasised that this research is not a comparison of Australia and Taiwan, but instead will utilise two different educational contexts to further examine the role of gender, socio-cultural and other issues in the decision-making process of CS studies across a range of settings. The inclusion of students who did not choose CS studies gives insight into the reasons for their non-participation. The following sections outline the current research design and rationale for data collection.

This research adopts a mixed methods approach (Johnson & Christensen, 2004), which consists of larger-scale quantitative surveys during the first phase to determine the general characteristics of the participants who were studying CS. The questionnaire was developed from a survey which has been used in previous studies. Since the effect of social, cultural, educational, familial and peer factors as stressed by Eccles (1994, 2005) in individuals’ decision making in educational choices cannot all be explored in surveys, findings from the quantitative surveys will further shape the semi-structured interviews in the second phase to examine the complexity of these factors further.

This research uses the Explanatory Design which presents qualitative data built upon initial quantitative results (Creswell & Plano Clark, 2007). This research also adopts the Participant Selection Model of the Explanatory Design, which uses quantitative information to identify and purposely select participants for a follow-up, in depth qualitative study (Creswell & Plano Clark, 2007). This research commences with quantitative questionnaires which identify the characteristics of the two groups of females studying CS in two different educational contexts, and then in-depth qualitative interviews are conducted in the second phase to explain why these results occurred.

The research sites are currently set at a prestigious government university in Taiwan, and a well-known university in Melbourne, both of which offer CS studies.

Approximately 80 to 100 participants are recruited in Australia and Taiwan respectively for the first phase. It is anticipated that this sampling size is sufficient as students will be answering detailed questionnaires for approximately 30 minutes. One group of participants is recruited in Australia and Taiwan respectively. Interviews will be kept to 10 people maximum in both Australia and Taiwan in Phase 2 with possibly random sampling. An interview guide approach is used to ask open-ended questions about the experiences and underlying reasons for female CS undergraduates’ participation in the field.

Questionnaires are analysed in accordance to Creswell’s (2009) recommendations for survey data.
Female contributing to the underrepresentation of female undergraduates in Computer Science in Australia

analysis by: a) reporting those who did and did not return surveys; b) discussing response bias; c) providing a descriptive analysis of all independent and dependent variables; d) identifying the statistics, and e) presenting results in tables or figures, and interpreting how these results answer the research questions. Data in the second phase will be qualitative in nature and will be analysed by: a) sorting transcribed and the field notes into different categories; b) gaining a general sense of the data; c) beginning detailed analysis with a coding process, by organising data into segments of data before assigning meaning to information.

Conclusion

Despite such disproportionately lower numbers of females as well as their discontinuation rate in CS education, female students who continue to enrol in CS programs were found to be more confident in their ability to compete with males, due to the sound maths and computer experience they gained prior to entering university (Fan & Li, 2005). Prior experiences with programming were also found to have a significant effect upon students’ performance in college CS courses, which shaped their attitudes toward computers (Fan & Li, 2005). It is therefore very important to investigate how higher female participation can be facilitated in order to address females’ underrepresentation in CS. This paper has introduced the research problem and the current state of female participation in Australian secondary and tertiary IT and CS education. The statistical data, as well as the literature both suggest that the underrepresentation of females has been an on-going issue for the past few decades. It is proposed that by using Eccles et al.’s (1983) model, in conjunction with data from two different educational contexts, the role of gender, socio-cultural and other possible issues can be further explored behind females’ participation in CS, as well as the non-participation for some females can be further explored. Questionnaires will provide a quantitative background against which the interviews can be shaped, taking into account of the results. However, in response to both the project objectives and outcomes, further improvisations will be made to the current research design over the coming months, such as including non-participants of CS, changing the size of participants, altering the selection of Australian participants, as well as considering the inclusion of both male and female participants in this project.

References

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Development(110), 7-14.