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Gender Diversity in Computing: An Environmental Perspective

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Abstract

Previous research conducted by the author investigated the socio-political backgrounds of two groups of female students studying computer-related university programmes. They came from distinctly different backgrounds and were enrolled at two institutions with very different legacies. The author found that socio-political factors, in particular the role of a dominant female household head and aggressive governmental affirmative action, had a significant effect on the girls' levels of confidence and subsequently on their decision to study computer-related courses. Based on this insight, the researcher undertook to look further into gender diversity with respect to self-perceived general computer confidence and self-perceived ability to program a computer. A sample of both female and male Information Technology students from very similar disadvantaged socio-economic backgrounds was surveyed. The sample of 204 students was drawn from all three years of the National Diploma in Information Technology. The author considered the following research questions:

(i) Do males and females studying computer-related courses have differing computer self-efficacy levels?

(ii) Do males and females studying computer programming have differing attitudes towards their ability to program?

(iii) Do males and females differ in their attitudes towards the programming learning environment?

The research instrument used in the study consisted of a questionnaire that comprised questions that tested the students' computing and programming self-efficacy as well as their attitude to gender stereotyping with respect to computer programming. The results of the survey indicate that there were more gender similarities than differences in the students' general computer self-efficacy and their confidence in their programming ability. However, there were very significant differences in the female and male students' perceptions of computing gender stereotyping. The female students supported the stereotypes that depicted females in a favourable light and rejected those that did not whilst the male students did just the opposite. It could be said therefore that the students generally had not been exposed to such typical stereotypes or, more importantly, if they had, they had rejected their validity within their own socio-cultural experience. The fact that more than 50% of both male and female students came from homes that were either headed by a female or had a female as the main breadwinner was a significant finding. The dominance of the female role in the upbringing of many of both

the female and male students in this study cannot be ignored when examining the results of the computer self-efficacy scale and the students' attitude to computer programming.

Keywords: Computer self-efficacy, gender and computing, computer programming, gender stereotyping

Introduction

In much international research there has been significant emphasis on gender differences in students' attitude to computing in general and computer science courses in particular. These differences are purported as having led to a drop in the number of young women studying computing-related courses at the post-secondary level (Camp, 1997; Margolis & Fisher, 2002; Miliszewska, Barker, Henderson, & Sztendur, 2006). In South Africa during the period 1991-1998, 31.1% of Computer Science and Information Systems degrees were awarded to women (Shapiro & Jacobs, 1999). Furthermore, another survey (SAITIS, 2000) reported that 13.4 of employees in the Information Technology sector in South Africa were black. In 1999 only 11% of black IT professionals were women (Qoza, 2000).

However, more recent research postulates that gender differences in the way men and women perceive and react to computing are largely a result of social and environmental conditioning. Blum, Frieze, Hazzan, & Dias (2007) reported on a case study which showed that from September 1999 as the learning environment in the undergraduate Computer Science classes at Carnegie Mellon University, USA, became more balanced, the culture of computing also changed in a way that enabled both women and men to succeed. This balance was brought about by de-emphasising prior programming experience in the entrance criteria whilst emphasising "breadth and leadership promise" (Blum et al., 2007, p.117) and introducing the Women@SCS programme which acted as a developmental structure for female Computer Science students. This finding is in marked contrast to the earlier pre-1999 Carnegie Mellon study which reported that women did not feel that they belonged both academically as well as socially in the Computer Science classes (Margolis & Fisher, 2002).

Miliszewska, Barker, Henderson, & Sztendur (2006) investigated high attrition rates of females in computing courses at Victoria University, Australia and reported no strong indication of gender differences in students' overall satisfaction with their Computer Science course. They put the high attrition rates in the first year down to the female students taking considerably longer than the males to settle into the course. This finding supports that of Blum et al. (2007) who reported that the changes in the Computer Science programme's "local environment" led to a more balanced situation in which both men and women felt comfortable.

Blum et al. (2007) went on to report on another case study conducted by Eidelman & Hazzan (2005) on Grade 12 students in Computer Science classes in Jewish and Arab co-educational high schools with identical syllabuses and matriculation examinations, where female Jewish students were under-represented whilst more than 60% of the Arab students were female. Their study concluded that this anomaly could be explained by the high level of encouragement that the Arab girls got from family, friends and teachers to succeed in a minority group collective culture and improve their social status.

In South Africa previous research by the author (Marsh, 2003) into three largely black universities showed that more female students (between 56% and 61%) than male students registered for the first year of computer-related courses. Again, this finding was contrary to surveys in countries such as the USA where the overall percentage of women in the IT workforce declined from 41% in 1996 to 32% in 2004 (Schiebinger, Finberg, & Henderson, 2006).

The author also previously investigated the socio-political backgrounds of two samples consisting of female students from distinctly different backgrounds and enrolled at two universities with very different legacies. She found that socio-political factors, in particular the role of a dominant female household head and governmental policy committed to empowering women, appeared to have a significant effect on the female students' levels of confidence and subsequently on their decision to study computer-related courses (Marsh, 2007).

During the Apartheid era, Black African males were used as cheap migratory labour on the mines and in the large cities. This exodus of men from the rural areas led to the breakdown of the nuclear family. The power of rural women in South Africa increased markedly as they became de facto heads of households. In 1993 South Africa's population was 40, 3 million people, 53% were women. Of all the households in the rural areas, 59% were female-headed. In 1999, 65% of South African rural households were managed and maintained by women (Statistics South Africa, 1999). The situation in the towns is very similar. "Racially discriminatory policies enforced by successive governments throughout the twentieth century left the African majority of the population in possession of only about 13 percent of the nation's land, and most of that of poor quality. As a result Black Africans, male and female, unable to achieve sustainable agricultural development, continue to flock to cities where many live in sprawling squatter camps. In these squatter camps, the nuclear family is not the norm and it is common for women as single parents, or the widowed, divorced and deserted to head families" (Marsh, 2007, p.136). A sample of the greater municipal areas from which the students in the study was drawn indicates that the majority of households in 2001 were headed by females (Statistics South Africa, 2001). These statistics are shown in Table 1.

Table 1: Sample of Gender-specific Head of Household (Census 2001)

Greater Municipal District	Number of Female-headed Households	Number of Male-headed Households	Total Households	%Female-headed Households
Alfred Nzo	54898	37424	92322	59%
Amathole	205598	183159	388757	53%
Chris Hani	97333	79631	176964	55%
OR Tambo	208745	132734	341479	61%

The author also found that prior computing exposure or the lack thereof did not influence the female students' choice to study computing at a post-secondary level. In fact, a lack of computing exposure might well have ensured that the female students from disadvantaged backgrounds had not been influenced by negative stereotyping of Information Technology careers (Marsh, 2007). These research findings on female students' attitude towards computing encouraged the author to investigate whether there were any significant gender differences between male and female students at her university with respect to their confidence in not only learning to use computers but also in learning to program them.

Research Context

The research presented here considers computer self-efficacy and its relationship to gender. According to Bandura (1977) self-efficacy can be defined as the beliefs a person has about his/her capabilities to successfully perform a particular task. Levels of self-efficacy are thought to be determined by such things as previous experience (success and failure), vicarious experience (observing others' successes and failures), verbal persuasion and affective state (e.g. feelings of anxiety or uncertainty) (Bandura, 1977). Self- efficacy levels have been shown to be related to choice of task and to the extent that students are motivated to persevere once they have begun the task. Because self-efficacy is based on self-perceptions regarding particular behaviours, the construct is considered to be situation specific or domain sensitive, thus computer self-efficacy beliefs can affect how a student carries out a computing task (Bandura, 1977; Betz & Hackett, 1981). For example, a student might feel unable to program a computer and whilst this inability may be real in that the individual genuinely may not have the necessary skills, it may simply be a belief which results in incapacity and poor motivation.

Self-efficacy beliefs have repeatedly been reported as a major factor in understanding the frequency and success with which individuals use computers. Compeau and Higgins (1995) found that people with high computer self-efficacy used computers more, enjoyed using them more and experienced less computer-related anxiety. Earlier research showed distinct gender differences in computer self-efficacy (Miura, 1987; Harrison & Rainier, 1992). Evidence was found that the gender difference between males and females was more marked when computers were used on an advanced level.

Research Questions

The author considered the following research questions:

(i) Do males and females studying computer-related courses have differing computer self-efficacy levels?

(ii) Do males and females studying computer programming have differing attitudes towards their ability to program?

(iii) Do males and females differ in their attitudes towards the programming learning environment?

Research Instrument

Since self-efficacy is essentially egocentrical, it needs to be measured directly rather than indirectly (Cassidy & Eachus, 1999). Direct measurement implies the need to use quantitative methods. Self-efficacy is therefore measured using self-report scales. The research instrument used in the study consisted of a questionnaire that comprised of 12 questions from the Cassidy & Eachus self-efficacy instrument designed to measure general computer self-efficacy (Cassidy & Eachus, 1999). This scale was chosen because it was shown to have high internal consistency, high test-retest reliability and is valid in assessing general computer self-efficacy. Cronbach's Alpha which measures the reliability of multi-item scales was applied to the 12-question scale extracted from the Cassidy & Eachus 30-question scale and it was found to be 7.8 which indicates an acceptable level of internal consistency. The author developed a further 8 questions to assess the students' perceptions of their ability to program the computer. When Cronbach's Alpha was applied to the 20-question scale which included the 8 questions created by the author to assess the students' self-efficacy specifically in relation to programming, it was found to be 7.5. This result also indicated an acceptable level of internal consistency for the whole self-efficacy measurement instrument.

The students were first asked to specify their gender, whether they had had prior computer exposure before enrolling at the University, the gender of the head of their household and the gender of the main income earner in the family. Then they were asked to indicate their level of agreement with a number of statements using a six-point Likert scale ranging from Strongly Disagree to Strongly Agree. Finally they were asked open-ended questions as to whether they liked or disliked programming and their reasons for their feelings and what skills they thought a good programmer needed and whether they had these skills.

The Sample

The sample of 204 students of the study was drawn from the three levels of students studying the National Diploma: Information Technology in 2007 and comprised 90 first year, 48 second year and 66 third year students. The overall number of students in the National Diploma programme was 323. The completion of the questionnaire was voluntary. Students attending the University typically come from under-resourced schools in rural areas in the Eastern Cape Province, the most impoverished area of South Africa which is still suffering from the ravages of the homeland policy of the apartheid regime. Most of these students are only partially financially supported by family and community and cannot pay their fees without government loans. In a previous study (Marsh, 2003) the author had found that these students came from a poor technological background with little or no exposure to digital devices except cell phones.

Research Results

Demographic Data

Of the 204 students who completed the survey, 111 (54%) were female and 93 (46%) were male giving a balanced sample population. They came from all three levels of the programme, thus the data was not biased by new students who may have been inexperienced in their judgements. They were typical of all the students in the programme and the University with respect to their racial origin and educational background. Table 2 gives a summary of the students' background data that was used in this study, namely, the students' gender in relation to prior exposure to computers and gender of the head of household and breadwinner. Previous research had emphasised the effect of prior computing experience on the levels of computer self-efficacy (Cassidy & Eachus, 1977; Compeau & Higgins, 1995). The presence of a female head of household and female breadwinner was chosen for investigation because it could indicate the strength of the female role-model in the students' formative years and thus could be a significant factor with respect to their responses to the questions.

Table 2: Sample's background data

	Gender			
	Female		Male	
	N	%	N	%
Prior exposure to computers	44	40	37	40
Female head of household/breadwinner	59	54	51	57

Table 2 shows clearly that there was no difference in the percentage of female and male students' exposure to computers before enrolling for the programme and thus this was dropped as an item of analysis from the study. However, the fact that more than 50% of both male and female students came from homes that were either headed by a female or had a female as the main breadwinner is a significant finding. It indicates the extent to which the socio-economic engineering policies of the previous apartheid regime disrupted the nuclear family and radically changed women's status within the family. It is feasible to claim that the dominance of the female role in the upbringing of many of both the female and male students in this study cannot be ignored when examining the results of the computer self-efficacy scale and the students' attitude to computer programming.

General Computer Self-Efficacy (CSE)

The Cassidy & Eachus CSE scale involves summing the responses to each statement in the scale after reversing the score for negatively phrased statements; the higher the score, the higher the computer self-efficacy. The frequency scores in percentages for female and male students are given in Figure 1. The mean percentage score for the female students was 75% and for the male students it was 76%. The Mann-Whitney U test carried out on the raw frequency scores showed no significant difference between the median scores of the two groups and thus provides a convincingly negative answer to the first research question:

> Do males and females studying computer-related courses have differing computer self-efficacy levels?

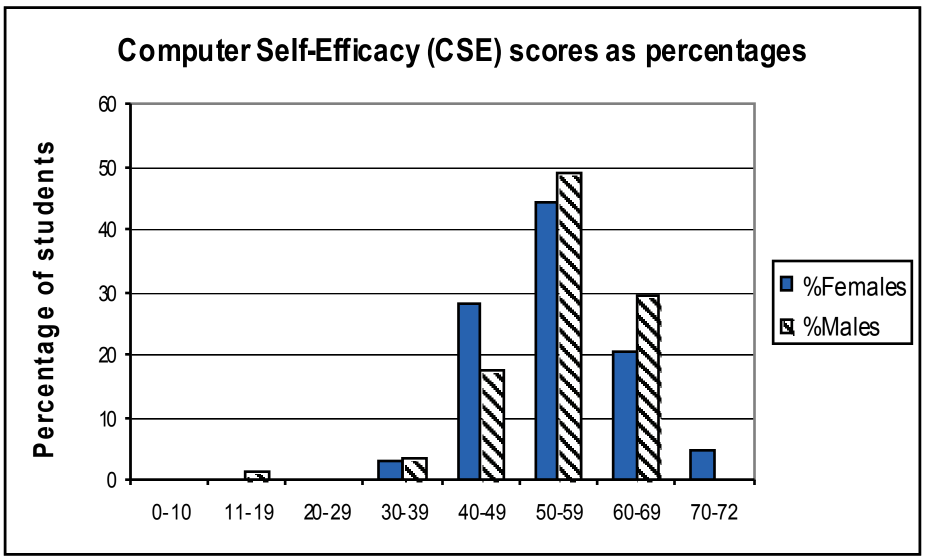

Figure 1: Computer Self-efficacy (CSE) scores

Programming-Specific Self-Efficacy

The sample of students was asked to respond to 8 statements relating to their confidence in their ability to program a computer, using a six-point Likert scale ranging from Strongly Disagree to Strongly Agree. The results are summarized in Table 3. The percentages indicate level of agreement: 'D' indicates the percentage of students who selected either of the two points (1 or 2) at the "Strongly Disagree" end of the scale; 'N' indicates the percentage of students who selected either of the two points (3 or 4) in the middle of the scale whilst 'A' indicates the percentage of students who selected either of the two points (5 or 6) at the "Strongly Agree" end of the scale.

Table 3: Agreement with programming related statements (as percentage of students)

Statements	Females			Males		
	D	N	A	D	N	A
	(1,2)	(3,4)	(5,6)	(1,2)	(3,4)	(5,6)
I learn to use different programming languages easily.	29	54	17	21	58	21
I have trouble learning the advanced programming skills.	29	53	18	35	44	21
I find it easy to organize and manage my computer programs.	14	55	32	15	34	52
There are times when I struggle to find the errors in my programs.	14	36	50	12	49	39
I never feel inferior to the other people in my classes.	12	40	48	19	30	51
I often ask other students to help me.	22	27	51	12	34	54
Others often seem to know what is going on with programming but I do not.	44	27	30	59	24	17
I can program the computer as well as any other member of my class.	19	34	47	17	36	48

A two-tailed Kolmogorov-Smirnov procedure was conducted in order to discover significant differences in the distribution of the responses from the female and male students but none was found. Thus the result delivers a negative answer to the second research question:

> Do males and females studying computer programming have differing attitudes towards their ability to program?

Students' Attitudes towards the Computer Programming Learning Environment

The students in the study were asked to respond to the open-ended question:

> *Do you like/dislike programming? Why?*

Not all the students responded: 84 (76%) of the females and 75 (81%) of the males answered and their responses are summarized in Table 4; 73% of the female respondents and 80% of the male respondents said they liked programming:

Table 4: Students' attitudes towards learning programming

Reasons for liking/*disliking* programming	**Gender**			
	Female respondents N=84		**Male respondents N=75**	
	Number of times the reason was cited	Percentage of respondents who cited the reason	Number of times the reason was cited	Percentage of respondents who cited the reason
Positive responses		%		%
Found it challenging	41	49	39	52
Considered programming to be fun	14	17	7	9
Enjoyed the structure/discipline of programming	6	7	6	8
Got a sense of fulfillment, felt in control	13	15	10	13
Negative responses				
Found it frustrating	*13*	*15*	*6*	*8*
Too structured, have to pay too much attention to detail	*3*	*4*	*8*	*11*
Found it confusing, too complicated	*16*	*19*	*6*	*8*

It is interesting to note that the highest percentage of both female (49%) and male students (52%) who liked programming indicated that they enjoyed it because it posed a challenge to them, whilst of the small minority who disliked programming, both female and male students alike claimed they found it confusing, frustrating and complicated. There were differences in that more females (17%) than males (9%) found programming fun and more females (19%) than males (8%) found it confusing and complicated; more males (11%) than females (4%) did not like the fact that programming was very structured and demanded attention to detail.

The students in the study were also asked to respond to the open-ended question:

What skills does a good programmer need?

There was a good response to this question with 83% of the females and 84% of the male students giving their opinions which are summarized in Table 5 below:

Table 5: Students' opinions as to skills required by good programmers

Skills needed by good programmers	Gender			
	Female respondents N=92		Male respondents N=78	
	Number of times the skill was cited	Percentage of respondents who cited the skill	Number of times the skill was cited	Percentage of respondents who cited the skill
		%		%
Self-discipline	24	26	19	24
Analytical/problem-solving skills	41	45	38	49
Creativity	14	15	12	15
Perseverance	48	52	24	31
Team skills	17	18	14	18
Intelligence	7	8	1	1
Self-confidence	2	2	1	1

A good number of both female (45%) and male (49%) students agreed that analytical and problem-solving skills were necessary to be a good programmer. They also agreed on self-discipline, creativity and team skills as being important. There was some difference in their opinions with regard to the importance of perseverance with 52% of female students and only 31% of male students listing it as a necessary skill for a good programmer.

The research question:

> Do males and females differ in their attitudes towards the programming learning environment?

can be answered by stating that there were many more similarities in the students' responses to the open-ended questions than marked differences. It is not possible to apply statistical measures to results obtained by analyzing the content of responses.

Students' Perception of Computing Gender Stereotyping

In order to discover whether the typical gender-related stereotypes often reported in the literature were accepted by the students in the study, they were asked to agree on a 6-point Likert scale to 4 statements. The scale ranged from Strongly Disagree to Strongly Agree. The results are summarized in Table 6. The percentages indicate level of agreement: 'D' indicates the percentage of students who selected either of the two points (1 or 2) at the "Strongly Disagree" end of the scale; 'N' indicates the percentage of students who selected either of the two points (3 or 4) in the middle of the scale whilst 'A' indicates the percentage of students who selected either of the two points (5 or 6) at the "Strongly Agree" end of the scale.

Significant differences in distribution obtained from a two-tailed Kolmogorov-Smirnov procedure are also indicated in the results shown in Table 6.

Table 6: Agreement with gender stereotypical statements (as percentage of students)

Statements	*p*	Females			Males		
		D	N	A	D	N	A
		(1,2)	(3,4)	(5,6)	(1,2)	(3,4)	(5,6)
Males are better programmers than females	**	64	13	24	29	13	58
Females are better at people skills than males	**	19	19	62	59	28	13
Males spend a lot more time messing around on computers than females	*	16	20	64	34	22	45
In group work the programming is usually done by a female	**	21	42	38	78	18	4

**$p<0.0001$ *$p<0.05$

Interestingly, there were very significant differences in the female and male students' perceptions of computing gender stereotyping, particularly with the three statements referring to gender-related ability to program and interact with people. The female students supported the stereotypes that depicted females in a favourable light and rejected those that did not whilst the male students did just the opposite. It could be said therefore that the students generally had not been exposed to such typical stereotypes or, more importantly, if they had, they had rejected their validity within their own socio-cultural experience. Acceptance of stereotypes, particularly gender-related stereotypes, is influenced by the process of socialization firstly within the family where such stereotypes are internalised and thereafter at school where they are reinforced.

Discussion

What has been learned from this research is that no significant gender differences were found and that female and male students had almost identical computer self-efficacy levels and very similar attitudes towards their ability to program a computer. They also expressed similar perceptions of the programming learning environment afforded them by their course of study. They did not support typical computer related stereotyping and rather expressed their affirmation of themselves and their gender group. Further investigation on a larger sample drawn from a wider spectrum of institutions of higher learning both within South Africa and in other African countries would confirm or dispute these findings.

It appears therefore that the problem being experienced in parts of the North-Western world with a drop-off of women studying computer science is not a universal one and possibly is a product of those specific cultures. The students in this study came from a social environment in which women headed and supported nearly 60% of the households. The results of this study indicate that their children give them and their gender the status which in other parts of the world is largely accorded to men. Many female and male children alike owe their places at universities to the support, strength and perseverance of these women who have fought for their children to achieve and to raise their status in a poverty-ridden society. Their mothers and grandmothers are more concerned with encouraging any seed of success than with perpetuating gender myths about which areas that seed should be planted in. No families who are struggling to succeed in postapartheid South Africa are going to consider a possibly lucrative career as an inappropriate choice for their children.

Conclusion

It can be argued that since gender is a social issue emanating from how we perceive our world and the men and women within it, problems with females not being attracted to computer-related study courses at university need to be tackled from a social, environmental perspective. It is interesting that the gender stereotypes discussed above succeeded in dividing the students in the study into their gender camps and perhaps, continually harping on the gender differences in the computing environment does the same with the same futile, misleading results.

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