

A Sub-Saharan Comparative Study of University Students' Attitudes towards Computer Programming

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ABSTRACT

Previous research conducted by the author investigated the socio-political backgrounds of South African female students studying computer-related university programmes and found that socio-political factors, in particular the role of a dominant female household head and aggressive governmental affirmative action, had 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. An investigation into gender differences in students studying computer programming courses at her university has now been followed by an investigation into students from very similar disadvantaged socio-economic backgrounds from two other sub-Saharan universities in Namibia and Tanzania. The results of the survey confirm that there were more gender similarities than differences in these students' general computer self-efficacy and their confidence in their programming ability. However, there were significant differences in the female and male students' perceptions of computing gender stereotyping.

Categories and Subject Descriptors

Computer Science Education

General Terms

Performance

Keywords

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

1. INTRODUCTION

In much international research there has been significant emphasis on gender differences in students' attitude to studying computing in general and programming 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 [4,10]. However, 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 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 and introducing the Women@SCS programme which acted as a developmental structure for female Computer Science students [3]. This view is supported by the ROSE project which carried out an international comparative study into the effect of students' values and culture on choosing science and technology careers [18]. Schreiner & Sjøberg reported that most girls in economically-developed countries had indicated that they did not want to work in the field of technology whereas in less economically-developed countries, e.g. Uganda, Ghana, Swaziland, Zimbabwe, Botswana, Phillipines, Bangladesh, India and Malaysia, both genders were keen to work with technology and the gender differences in the scores were not as pronounced as in the former countries. In South Africa, previous research by the author [12] into three largely black, disadvantaged universities showed that slightly more female 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 [17].

The researcher also 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 had a significant effect on the female students' levels of confidence and subsequently on their decision to undertake and persevere in computer-related courses [13]. She then studied gender differences between male and female students with respect to their confidence in not only learning to use computers but also in learning to program them and found no significant differences [14]. This finding contrasted with

reports indicating that female students shy away from programming-intensive curricula and careers, such as a recent UK study that found that females who comprised only a quarter of the IT work force were largely employed in the lower-skilled, less programming-oriented occupations such as database and user support [7].

In order to understand these South African IT students better, the researcher has now extended this study to include CS/IT students in two other sub-Saharan countries.

2. RESEARCH CONTEXT

The research presented here considers computer self-efficacy and programming self-efficacy and their relationship to gender. According to Bandura, 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 factors as previous experience, vicarious experience (observing others' successes and failures), verbal persuasion and affective state (e.g. feelings of anxiety or uncertainty) [1]. 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 domain specific thus computer self-efficacy beliefs can affect how a student carries out a computing task [1,2,6,9,11]. 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.

2.1 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?*

2.2 Research Instrument

Since self-efficacy is intrinsically tied to one's self-worth, it needs to be measured directly rather than indirectly [5]. 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 contained twelve statements from the Cassidy & Eachus self-efficacy instrument designed to measure general computer self-efficacy [5]. These twelve statements of the original 30 were chosen for their applicability to students who were already in their second year of a university IT or CS programme. The Cassidy & Eachus CSE 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-statement scale extracted from the Cassidy & Eachus 30-statement scale and it was found to be 0.78 which indicates an acceptable level of

internal consistency. The author developed a further 6 statements to assess the students' perceptions of their ability to program the computer. When Cronbach's Alpha was applied to the 18-statement scale which included the 6 statements created by the author it was found to be 0.77. This result also indicated an acceptable level of internal consistency for the self-efficacy measurement instrument as a whole. The students were asked to indicate their level of agreement with all 18 statements in the instrument by using a six-point Likert scale ranging from Strongly Disagree to Strongly Agree. The responses to each of the statements were summed after reversing the score for negatively phrased statements; the higher the score, the higher the self-efficacy.

In addition to the self-efficacy scale, students were also asked to specify their gender, the level of their study, the programme they were studying, whether they had had prior computer exposure before enrolling at university, the gender of the head of their household, the gender of the main income earner in the family and who in their family had been most influential in their choice of an ICT career. They were also asked to respond to two statements typifying gender stereotyping with regard to programming ability.

2.3 The Sample

The number of female and male students from the three universities who participated in the study is shown in Table 1. They were drawn from all levels of their respective undergraduate programmes. These programmes ranged from a National Diploma in Information Technology to degrees in Computer Science and Computer Engineering. The smaller ratio of female to male students in the Tanzanian sample is representative of the gender ratio of students studying computer-related courses at that university.

Table 1. Composition of Student Sample

	Female students	Male students	Total students
South Africa	104	85	189
Namibia	27	58	85
Tanzania	46	156	202

3. RESEARCH RESULTS

3.1 Demographic Data

Initially, two specific items were used in the study, namely the student's gender in relation to prior exposure to computers and the gender of the head of the student's household. There were reasons for these two choices:

The first item was chosen because previous research had emphasised the effect of prior computing experience on the levels of computer self-efficacy [5,6]. The choice of the second item of study was contingent upon the fact that the presence of a female head of household 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.

The importance of this second specific item of the study might need further justification. During the colonial era in South Africa and Namibia and to a lesser extent in Tanzania, Black African males were used as cheap migratory labour in the large cities and mines. This exodus of men from the rural areas led to the breakdown of the nuclear family. During the course of the twentieth century, the power of rural women and then later, of urban women, increased markedly as they became de facto heads of households and this trend unfortunately persists today. With the advent of rapid urbanisation since independence in Tanzania and Namibia and the lifting of apartheid population control laws in South Africa, many people live in sprawling squatter camps in which the nuclear family also is not the norm; it is common for women as single parents by choice or by desertion to head families [13].

On analysis of the results, very little difference in the percentage of female and male students' exposure to computers before enrolling for their university courses was found and thus this was dropped as an item of analysis from the study.

However, as Table 2 indicates, in the South African sample half (50%) of the female student respondents came from homes that were headed by a female; a similar trend is seen in the Namibian sample (46%) whilst in the Tanzanian sample (31%), it is present but not as pronounced.

Table 2: Students from female-headed households

	% All student respondents	% Female students	% Male students
South Africa	48	50	44
Namibia	27	46	18
Tanzania	23	31	21

These findings are not surprising considering that in 2001, 65% of South African rural households [17] and 45% of Namibian households [15] were female-headed whilst in 2004, 24% of Tanzanian households were in a similar position [20]. These figures are considerably higher than the figures from the more economically-developed countries; for example, the 2006 census in the United Kingdom found that 14% of family households were headed by a female [16].

It is feasible to claim that the influence of the female role in the upbringing of the students in this study, particularly the female Namibian and South African students, cannot be ignored when examining the results of the computer self-efficacy scale and the students' attitude to computer programming.

3.2 General Computer Self-Efficacy (CSE)

The twelve statements extracted from the Cassidy & Eachus scale, with small language modifications to remove colloquialisms, follow:

- I can deal with most of the difficulties I experience when using computers.
- I find working with computers very easy.
- I am not sure of my abilities to use computers well.

- Computers make me more productive.
- I often have difficulties when trying to learn a new computer application
- Most of the computer applications I have learned have been easy to use.
- I am very confident in my abilities to use computers.
- I find it difficult to get computers to do what I want them to do.
- At times I find working with computers very confusing.
- I seem to waste a lot of time struggling with computers.
- I consider myself a skilled computer user.
- I find working with computers very frustrating at times.

Although not as powerful as the parametric t-test, the Mann-Whitney U test was chosen for comparison of the female and male scores because it makes no assumption about the distribution of the data. The mean percentage Computer Self-Efficacy (CSE) scores for female and male students from the three universities and the test results are given in Table 3.

Table 3. Computer Self-Efficacy Scores

	CSE Scores as Percentages		Mann-Whitney Results
	Female students	Male students	<i>Two-sided p</i>
S Africa	75	77	0.3288
Namibia	72	76	0.1051
Tanzania	69	73	0.0545

This test carried out on the raw frequency CSE scores showed no significant difference (all p values >0.05) between the median scores of the female and male students in the three samples. Control checks using ANCOVA (analysis of covariance) on the level of study and the programme being studied did not affect the lack of significant difference in the CSE scores. Thus these findings provide a negative answer to the first research question:

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

3.3 Programming-Specific Self-Efficacy (PSE)

The six statements relating to programming self-efficacy (PSE) which follow were added to the CSE instrument since it did not contain any specific to programming:

- I learn to use different programming languages easily.
- I have trouble learning the advanced programming skills.
- I find it easy to organize and manage my computer programs.
- There are times when I struggle to find the errors in my programs.
- Others often seem to know what is going on with programming, but I do not.

- I can program the computer as well as any other member of my class.

Table 4: Programming Self-Efficacy Scores

PSE Scores as Percentages			Mann-Whitney Results
	Female students	Male students	Two-sided <i>p</i>
S Africa	60	64	0.0521
Namibia	61	61	0.8314
Tanzania	53	62	**0.0003

The Mann-Whitney U test carried out on the raw frequency PSE scores showed no significant difference (both *p* values > 0.05) between the median scores of the South African and Namibian female and male students. However, there was a highly significant difference ($p < 0.001$) in the higher scores of the Tanzanian males. Tanzanian females, for example, were more inclined to agree with the statement:

“Others often seem to know what is going on with programming, but I do not”.

A Mann-Whitney U test also showed a significant difference in the scores of the South African and Tanzanian females ($p < 0.05$) and Namibian and Tanzanian females ($p < 0.05$). The fact that a relatively high percentage of the female students in the first two samples came from female-headed households might account for their confidence in their ability to program computers. On the other hand, the fact that the Tanzanian female students were in a small minority (less than a quarter of the students in the two CS programmes in the university) could easily have led to their feeling uncomfortable in their programming classes. This is an area for further investigation.

Control checks using ANCOVA (analysis of covariance) on the level of study and the programme being studied did not affect the lack of significant difference in the scores of the South African and Namibian students.

3.4 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 two stereotypical statements. The Likert scale ranged from Strongly Disagree to Strongly Agree with opposite end-points ranging from Strongly Disagree (1) to Strongly Agree (6). Table 5 shows the average scores for the student responses and the results of a two-tailed Kolmogorov-Smirnov (KS) procedure into the differences in distributions of the responses in the gender groups per country sample.

Interestingly, there were several very significant differences in the female and male students’ perceptions of computing gender stereotyping referring to gender-related ability to program.

Table 5: Responses to gender stereotypical statements

Statement	Average scores			KS Results
		F	M	Two-sided <i>p</i>
Males are better programmers than females	S Africa	2.5	4.3	**0.000
	Namibia	2.4	3.3	0.397
	Tanzania	2.3	3.4	**0.0004
In group work the programming is usually done by a female	S Africa	3.9	1.7	**0.000
	Namibia	3.1	1.8	**0.0009
	Tanzania	2.7	1.9	*0.0082
	* $p < 0.05$ ** $p < 0.001$			

Generally speaking, 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. This was particularly true of the South African students. In interviews the researcher had conducted previously with a random sample of the female South African respondents, this affirmation of their ability was supported [13]. Space allows only one excerpt:

“It’s being different, like in South Africa. Because, in the past, most of the women (were) like depressed. Men were dominating on both sides. Women were there to be like wives, cook and bear children, but now things have changed now we have this power that you can do whatever you can do. I’m so glad that I’m a woman doing IT so that I can prove it that women have this ability to do whatever men do.”

The answer to the second research question

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

has to be a qualified one. As shown in Table 4, the case of the South African and Namibian samples, there were no gender differences in respect of the students’ perceived ability to undertake programming courses. The Tanzanian sample, however, did show marked gender differences in this regard.

4. DISCUSSION

What has been learned from this research is that no consistently significant gender differences were found in the students’ perceived ability to work with a computer. This finding is in marked contrast to an earlier South African study that found that first year male Computer Science students had significantly higher computer self-efficacy than their female counterparts [8]. However, a closer look at the sample of students in that study showed that most of the students came from an advantaged, middle-class, urban, mainly white environment. The students in this study, on the other hand, came mainly from a disadvantaged, poor, black environment.

However, whilst South African and Namibian students’ attitudes towards their ability to program a computer did not differ by gender, the Tanzanian students’ attitudes did. This difference might be attributed to the fact that the prevalence of female-

headed households in the Tanzanian sample was not as marked as in the case of South Africa and Namibia and also to the fact that females were under-represented in their CS classes and also within the university itself.

On the whole this study's findings support those of other authors who maintain that the drop-off of women studying computer-related university programmes is not a universal one but rather a product of the particular countries' specific values and cultures. Schreiner & Sjøberg maintain that the culture and material conditions of a country influence what young people think is important and that highly developed post-materialistic Western countries' values tend towards such matters as preserving the environment [18]. The students in this study come from an economic environment of early industrialisation focused on infrastructure improvement and poverty alleviation in which technology is a driving force. This economic environment coupled with a sociological environment of female leadership and support might have exerted an influence on both male and female's attitudes towards studying ICT programmes and programming courses.

Many female and male students 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. However, it is particularly the South African and Namibian female students who have been affirmed and encouraged by their unique socio-economic circumstances. Another interview excerpt echoes the voices of so many of the young South African women who were previously interviewed [13]:

"She (the student's grandmother) is a very strong (person) and I rely on her and one day I hope I can be as strong as she is. She always told me that there's nothing specifically for males, if a male could do it then a female could do it".

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