Women in Computing Around the World

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Abstract

This paper describes the participation of women in computing in more than 30 countries, by focussing on participation at undergraduate level. A brief discussion covers how societal and cultural factors may affect women's participation. Statistics from many different sources are presented for comparison. Generally, participation is low – most countries fall in the 10-40% range with a few below 10% and a few above 40%.

Invited Papers

1. Introduction

This paper presents a picture of the participation of women in computing around the world. Authors have published much on the low participation of women in computing in the USA, the United Kingdom, and Australia; and there are researchers active in other countries seeking to describe and understand their own situations. It is important to consider the situation in different countries to avoid incorrect assumptions and to find appropriate solutions.

Recently, the ACM's Committee on Women in Computing (ACM-W) has taken steps to obtain a global picture of the situation with the introduction of the ACM-W Ambassador program. Each ACM-W Ambassador will provide information about the status of women in computing in their country via a website – links to these sites can be found at <http://www.acm.org/women>.

This paper focuses on participation in academic study, specifically university undergraduate level, as this is a relatively available statistic. Other measures will be used to fill out the picture where necessary. People have described computing as a discipline that contains aspects of science, engineering, and mathematics [16]. Because of this complex nature, it is not possible to infer the situation of women in computing from information about women in science, or information about women in engineering. Hence, published statistical information that aggregates disciplines is not useful in determining the status of women in computing. This article presents mostly information about computing, but it also presents general information that will broaden the picture.

The next section briefly considers how cultural factors affect the participation of women in computing. The main section of the paper then presents data from different countries. The data are presented compactly in tables, and details of how the tables can be interpreted are given. Finally, a brief discussion of the data is given.

2. The Effect of Culture and Society

The reasons that women choose to study computing will vary from culture to culture, and from country to country, and it is beyond the scope of this paper to consider this issue in detail. When seeking solutions for women's low participation in computing, it is important to consider all cultural and societal factors that may affect this participation. This also allows us to identify when a solution from one country may or may not be suitable to use in another country.

For example, Mukhopadhyay [35] argues that the 'internal' 'self-selection' model used to explain the participation of women in science in the United States cannot be applied to India. A more appropriate model is one in which the family is a decision-maker where the decisions are guided by collective family goals. One of these goals is ensuring that daughters 'marry well, upholding family honour' [35,p. 14], and education is perceived as posing social dangers as well as conferring benefits in achieving this goal. The model explains why there is lower participation in the applied sciences compared to the pure sciences. The applied sciences such as engineering and technology are perceived to be highly male dominated and hence present more dangerous social contexts than pure sciences such as physics, chemistry and mathematics which can lead to more 'respectable' jobs such as a position at a women's college.

In 1994, *Science* published a special issue comparing women in science across a number of cultures and countries. Factors associated to high numbers of women in science are [4]:

- Girls-only schooling (India, predominantly Catholic countries)
- Compulsory mathematics and science through secondary school (Poland, Italy)
- Family-friendly societies (Israel, Mediterranean countries)
- Perceptions of science as a low-status occupation when compared to disciplines such as engineering (Portugal, Turkey, India)
- Class issues (India, Latin American countries), and
- Recently developed science capabilities (Portugal, Mexico, Argentina).

It is not clear whether these factors apply to computer science as well. Researchers have investigated cross-cultural gender issues in computing and some of these studies are now briefly described. Janssen Reinen and Plomp [28] considered primary and secondary school students from Austria, Bulgaria, Greece, India, Japan, Latvia, the Netherlands, Slovenia and the USA surveyed in 1989 and 1992. All countries showed gender differences in basic knowledge of information technology and simple computer skills except Bulgaria, USA, and India. With respect to perceptions of relevance of computing, Austria, the Netherlands, and Latvia showed gender differences (where boys were more positive about relevance). Generally, female students showed less enjoyment of computer use. Differences were also found in terms of parental encouragement, access to computers and role models. The lack of difference in ability and knowledge in the USA could possibly be attributed to high number of female teachers, parental encouragement, and computer use outside school. In Bulgaria, it could be attributed to high number of female teachers. For the Indian students, there were high levels of parental encouragements for both male and female students, and the lowest level of computer use for both male and female students from any country.

In their study of university students in 23 countries, Weil and Rosen [67] found that in Thailand, Italy, and Kenya, men were significantly more anxious about computers, whereas in Israel and Hungary, women were significantly more anxious. There were significantly more male technophobes in Kenya, and significantly more female technophobes in the USA, Hungary, and Australia. In the USA, Singapore, Kenya, Israel, Hungary, Czechoslovakia, Belgium, Australia, and South Africa [11], men had significantly more positive cognitions with the reverse in Northern Ireland. In one country, Indonesia, female students had significantly more experience than males, and the opposite was found in Yugoslavia-Croatia, Thailand, Mexico, Japan, Italy, India, Hungary, Germany, Czechoslovakia, and Australia. These results indicate no consistent pattern, but do show definite differences between countries.

Gender and country based research has been done into computer self-efficacy. Computer self-efficacy describes to an individual's beliefs about their ability to be successful when using computers. An aspect of computer self-efficacy research concerns the 'We can, I can't' paradox [18]. This describes how a member of a group (for example, a woman) believe that the group (for example, all women) can succeed at the activity, but yet believes that they personally cannot succeed at that activity.

Makrakis [32] considered computer self-efficacy amongst Japanese and Swedish secondary school pupils, and found no gender differences in either country. However, Japanese students believed that as a group they could succeed but were less confident about their own individual ability showing the 'We can, I can't' paradox. This did not occur amongst the Swedish students, and this difference was attributed to a greater focus in Japanese society on group identity.

A similar study investigating self-efficacy amongst Romanian and Scottish higher education students [17] found differences between the male and female students with women students less confident about their abilities with advanced skills and file and software skills. These differences were also evident when comparing male and female students within each country. The fact that there were significant differences is self-efficacy between male and female Romanian students is interesting considering that Romania has historically had a much higher percentage of female technologists, engineers and scientists.

Collis and Williams [12] found that there were fewer gender-based differences between Chinese students than with Canadian students when investigating attitudes to computers. The main gender-based difference for Chinese students was in the perceptions of women's abilities where female students were much more positive than male students. This difference also occurred amongst the Canadian students. Other differences between female and male students in the Canadian sample was that male students were significantly more positive about computers and female students were significantly more negative about the impact of computers on society.

Within a country, students of different backgrounds can have different experiences. Von Hellens and Nielsen [66] note that amongst IT students at an Australian university, female Asian students feel they are ignored by non-Asian students and male Asian students, whereas female non-Asian students feel they are the focus of sexual harassment and unwanted positive discrimination.

Not all countries have low participation by women. In 1987, more than 50% of application/analyst programmers and system analyst/designers in Singapore were female, and the majority of graduates from computer courses were female [30]. Uden [63] argues that this occurs because of government promotion of the use of computers, perceptions of good career prospects in IT, a preference amongst women for computing as opposed to engineering which also pays well, exposure to computers at schools level in a gender-neutral manner, and assistance with domestic responsibilities by older family members or employees.

As can be seen from this discussion, these research results do not show a clear pattern that can help to explain why the differences between men and women with respect to computing occur in some countries and cultures, and not in others. Further research is required.

3. Women's Participation in Computing

The specific measure that will be considered in the tables that follow is women as a percentage of the total number of undergraduate computing students or computing graduates. Hence, the data collected concentrates on students taking computing at tertiary education level as a major subject, in the sense that their qualification will focus on computing. In some cases, the data refer to students in a particular year of study who are taking computing courses at a major level. Where it was not possible to determine the type of course, the course has been briefly described. Most data are drawn from universities, but as the tertiary education system varies from country to country, information has been drawn from other types of institutions such as technical colleges. Other data not specific to computing at tertiary level will be used to give a more complete picture.

Not all countries publish easily available national data recording the percentages, so data have been obtained from two other sources: data from individual universities and data reported by individuals attending or presenting classes at university level. There are four tables, Tables 1-4, grouping together countries from similar geographical areas. For a discussion of the approach taken in collecting data, see [21].

3.1 Reading the Tables

The first four tables have the format described below. Information that is unclear is marked with a question mark, and figures that are approximate are indicated with ~.

Country

Some countries have more than one entry, when the data are reported from different sources. The data are presented as discovered, so there is the possibility of contradictory or disparate data.

Data

In this column, a percentage is given calculated from the total number of women and the total number of people, and if available, the actual number of women is given in brackets.

Year

This attribute is the year (or years) from which we derive the data. Where year information is an academic year split over two calendar years, the most recent year of the two is used in these tables.

Trend

This indicates any trends in the percentage data. If the percentage in the Trend column is less that that in the Data column, this means that since the year given in the Trend column, there has been an overall trend for the data to increase. If the percentage in the Trend column is more than that in the Data column, then since the year given in the Trend column, there has been a trend for the data to decrease. If 'none' appears in the trend column, then since the year indicated in the Trend column, there has been no discernible trend. In some cases, the trends have been inferred from the data available, and in other cases, it has been described as a trend by the source of the data.

Type

This column covers the level and the discipline to which the data refers. As mentioned above, the data collected refers to the study of computing at major level at tertiary institutions. Where it was not possible to determine whether this was the case, the category 'Other' has been used.

The abbreviations for level are:
'UG' – undergraduate study,
'fy' – final year,
'1y' – first year,
'dist' – distance learning,
'Deg' – first/undergraduate degree (this category excludes postgraduate/graduate qualifications),
'PG' – postgraduate study,
'Acc' – applicants accepted to degree programmes,
'UG&MSc' is used when figures are given for both undergraduate and MSc study.
If the level could not be determined from the source, the level is not given.

The abbreviations used for discipline are:
'CS' – Computer Science,
'Inf' – Informatics,
'IT' – Information Technology,
'IT&T' – Information Technology and Telecommunications,
'Cmp' – Computing,
'CmpSci' – Computing Science,
'CmpStd' – Computer Studies,
'CSS' – Computer and System Sciences,
'CSys' – Computer Systems,
'BusCmp' – Business Computing,
'Tech' – Technology,
'CT' – Computer Technology,
'TechInf' – Technical Informatics, and
'IS' – Information Systems.
The word 'Other' is used when the data are not about major-level computing at university or a similar tertiary institution, and a footnote is given describing the data.

Source

If the data reflect national information, 'National' is used. 'Inst' is used for published or official data from a specific university or institution, and 'Insts' for similar data from a group of universities or institutions. 'Ind' is used for data given by an individual. For both institutional and individual data, the names of the institutions are given where known.

Table 1: Africa

Source: If the data is national, 'National' is used. 'Inst' is used for published or official data from a specific university or institution, and 'Insts' for similar data from a group of universities or institutions. 'Ind' is used for data given by an individual. For both institutional and individual data, the names of the institutions are given where known.

Country	Data	Year	Trend	Type	Source
Botswana	10% (2)	1998		UG fy, CS	Ind, U of Botswana[a] [53]
Eritrea	< 10%	2001		UG, CS	Ind, U of Asmara[b] [34]
Madagascar	11.1%	1997?		Other[c]	National [65]
Kenya	11.1% (3)	2001		Deg, CS	Ind, U of Nairobi [46]
Libya	35.7% (606)	2002		Deg, CT	Insts, Alfateh U, 7th of April U, Altakadum U [2]
Nigeria	31.3% (10) 20%-30% 32.6%	1997 1994-6 1994	 28.7% 1991	UG, CS UG, CS CS	Ind, Ogun State U [50] Ind, U of Benin [1] Insts, Nigerian polytechnics [24]
South Africa	32.1% (337)	1998	none 1991	Deg, CS&IS	National [48]
Tanzania	3% (2)	1996	14% 1993	UG, Inf	Insts, U of Dar-es-Salam, Sokoine And Muhimbili [65]
Uganda	~27% (9-10)	2000		UG fy, CS	Ind, U of Makerere [22]
Zimbabwe	40.7% (341)	1996		CS	Insts, Technical colleges [65]

[a] The University of Botswana is the only university in Botswana offering a BSc in Computer Science.
[b] The University of Asmara is the only university in Eritrea.
[c] Computer Science higher education teachers.

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Table2: Asia and Australasia

Country	Data	Year	Trend	Type	Source
India	20.3% (15) 11.3% (11) 7.84% (22,857) 28.42% (27)	2002 1996 1994 1993	none 1993 none 1992 7.3% 1982	UG, CS CSS Other[a] IT	Inst, Annamalai U [58] Inst, J Nehru U [10] National [10] Inst, Andhra U [23]
Iran	41%	1999?		CS	Insts, vocational and training institutions [49]
Pakistan	18.2% (8) 4.99% (685)	2000 1998		PG, CS Other[b]	Insts, Q.A.U. Islamabad [5] Insts [5]
Malaysia	51.4% (2,167)	1991		Other[c]	National [40]
Singapore	> 50%	1987?		Other[d]	Insts [30]
Thailand	55% (158,286)	1998	57.2% 1996	Other[e]	Insts [37]
Turkey	20.4% (1,753)	2001	18.3% 1997	UG, CSys	National [38,3]
Australia	19% 49%	1998 1995	22% 1994 ~35% 1990	IT&T UG, BusCmp	National [39] Inst, Victoria U [13]
New Zealand	20% 26% 17-23%	1992-6 1989-96 1990-6		Deg, CS&IS UG 1y, Cmp UG 1y, CS	Inst, Massey U [47] Inst, Auckland U [47] Inst, Victoria U of Wellington [7]

[a] Students studying Engineering and Technology. National statistics do not give figures for computing [10]. Most computer science departments are located in faculties of Engineering and Technology [23].
[b] Enrollment at universities of engineering and technology.
[c] Students enrolled for computer related courses at tertiary institutions.
[d] Graduates from computer courses from four public institutions.
[e] Participation in computer courses at private vocational institutes.

Table 3: Europe

Country	Data	Year	Trend	Type	Source
Czech Republic	9.6% (51) 25%	2001 1989-94		UG, Inf UG&MSc, CS	Ind, Masaryk U [9] Ind, Charles U [57]
Denmark	6%	1996		CS	National [44]
Finland	20%	1997	31% 1985	UG 1y, IT	National [44]
Germany	10.5% (610) 8.8% (46) 9% 9.5% (2,958)	2000 1999 1999 1994	16.2% 1995 18.8% 1979	Deg, Inf Inf Inf UG, Inf	National [56] Inst, U Karlsruhe [29] Inst, RWTH Aachen [29] National (West Germany) [42]
Iceland	24% (47) 28% (42)	2000 1999		CS UG, CS	Inst, U of Iceland [51] Inst, Reykjavík U [51]
Netherlands	6.6% (7) 18% 12%	1999 1992 1991		TechInf UG dist, Inf Tech	Inst, Technical U Delft [29] Inst, Open U of the Netherlands [15] Insts, traditional universities [62]
Norway	23.2% (1,691) 34% (69)	1999 1998	20.4% 1996 6% 1996	Tech CS	National [55] Inst, Norwegian U of Science and Technology (NTNU) [41]
Slovenia	6.7% (94)	2000?		CS&Inf	Inst, U of Ljubljana [54]
Spain	25.2% (1,101)	1998		Deg, Inf [a]	National [26]
Sweden	30% (16,245) ~10% (~24)	2000 1990-4		UG, Tech UG, CS	National [59] Inst, Uppsala U [6]
Switzerland	11.4% (122) 6.5% (2)	2001 1998	4,2% 1995	UG, Inf Deg, Inf	Inst, ETH Zürich [31,20] Inst, EPFL [25]
UK	19% (3,444)	1999		Acc, CmpStd	National [43]

[a] Students graduating with Diplomado Informática, Ing. Téc. Informática de Sistemas, and Ing. Informática.

Table 4: North and South America

Country	Data	Year	Trend	Type	Source
Canada	24% (211) 12% (55)	2000 1997	16% 1993	UG, CS UG, CmpSci	Inst, UBC [61] Inst, Simon Fraser U [60]
USA	26.7% (7,166)	1998	37.1% 1984	Deg, CS&IS	National [36]
USA & Canada	20.4% (2,372)	2000		Deg, CS	Inst, PhD granting departments [8]
Mexico	39.2% (55,154)	1999	43.1% 1992	UG, Cmp [a]	National [27]
Brazil [b]	34.8% (5,641) 20%	1993 1993		UG, CS UG, CS	National [33] Insts, U of São Paulo, U of Campinas [33]
Bolivia	34.1% (15)	1997		Inf	Insts, private universities [45]
Guyana	54.5% (22)	2001	none 1998	Deg, CS	Ind, University of Guyana [c] [14]

[a] Students registered for a Licenciatura in Computación y Sistemas.

[b] Other data records 5-10% female students at the University of São Paolo, in the last ten years and not more than 20% at other institutions in the same period [52].

[c] The University of Guyana is the only university in Guyana.

3.2 Other data

The 1998 UNESCO Statistical Yearbook [64] gives figures on participation on women in the subject area Mathematics and Computer Science, in terms of both enrollment and graduates. These data are of interest, but must be considered with care as a high participation in mathematics may mask a low participation in computer science or *vice versa*. The 1999 editions of the Statistical Yearbook does not give this breakdown – it only gives figures of female participation for the broad fields Education, Humanities, Social Sciences, Natural Sciences, Medical Sciences and Others – and no future issues are planned of this yearbook [19]. A summary of the statistics from the 1998 UNESCO Statistical Yearbook can be found in [21].

3.3 Discussion

As can be seen from the tables, there is a wide range in participation in computing by women. As the information covers different courses and different levels, it is difficult to do a direct comparison between countries. We can see from the data that participation is between 10% and 40% in most countries and courses, with a wide spread in this range. Hence, there is a strong indication that there is an under representation of women in computing worldwide, at least in terms of undergraduate participation. There are some countries and courses where women's participation is below 10%, some with participation above 40%, and a few where women are in the majority. Some countries and courses show an increasing trend and some decreasing, so it is not possible to predict future changes. To conclude, women appear to be under represented in the discipline of computing, when we consider the figures for undergraduate participation, and there is no clear indication that this will improve in the near future. Ongoing research is required to determine causes and solutions.

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Request for Information

The research that led to this article is ongoing and the author appreciates any information about countries not discussed in this article or more recent information about countries mentioned here. Please refer to the author's web page at <http://www.cs.wits.ac.za/~vashti> for updated information.

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