GENDER DIFFERENCES AND ACHIEVEMENT IN COMPUTER SCIENCE AND ENGINEERING

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ABSTRACT

This study focuses on gender differences at University level of education regarding with Computer Science and Engineering (CS&E). For this reason, 1957 diplomas of Computer Engineers were studied. These diplomas have been taken through a 21 year period of time at the Computer Engineering and Informatics Department (CEID), University of Patras, Greece. In particular, the data of these diplomas were studied in order to investigate if there is any relation between gender and: a) diplomas taken through this 21 year period of time, b) achievement in terms of diploma's grading, and c) duration of undergraduate studies. The analysis of the data shows that during 21 years of graduation at CEID: a) male graduated students were three times more than the female ones, b) regarding achievement, no significant differences exist between male and female graduate computer engineers, and c) female students complete their studies earlier than their male colleagues.

KEYWORDS: GENDER DIFFERENCES, COMPUTER SCIENCE AND ENGINEERING, ACHIEVEMENT

1. INTRODUCTION

In the first decade of this new century, it should become apparent to everyone that the computing and information fields, broadly defined, will have a profound impact on every element of every person's life. However, not only are more men than women actively involved with computers but many believe that it is more natural for men to study Computer Science (CS) than for women (Galpin, 2002; Gürer and Camp, 2002). In fact, women are underrepresented in all fields of Computer Science: undergraduate and graduate studies (Galpin, 2002; Wardle and Burton, 2002), CS Industry (Duplantis, MacGregor, Klawe and Ng, 2002) and CS Academic field (Camp, 1997). Regarding CS, women participation is between 10% and 40% in most countries and courses, with a wide spread in this rage (Galpin, 2002). Thus, it is crucial to address the important underlying issue: Is there anything wrong with so few women studying or working in computing?

It is well known that, active involvement by women in the world of computers dates from the early 19th century, where women more than men were occupied with these machines because of their experience in typing and telephony (Lee, 2002). In addition, there are many women-pioneers who have contributed significantly to computer science with their great achievements (Gürer, 1995). Despite this, female Computer Scientists have been mainly treated - and sometimes still are - as inferior scientists when they cooperate with their male counterparts, not to mention the fact that many people believe that men are more capable of using a computer than women (Gürer and Camp, 2002).

A number of studies have demonstrated that women usually entered to Computer Science Departments with diminished self-confidence in using computers in comparison to their male colleagues (Clayton and Lynch, 2002; Cohoon, 2002; Fisher and Margolis, 2002; Jepson and Perl, 2002; Moskal, 2002; Gürer and Camp, 2002**)**. The most harmful factors causing this low self-confidence are: a) the lack of early experience

with computers due to the fact that computer games are mainly male-oriented as their content is representative of a male-culture: guns, war, fights, aggressive scenes, male figures, vivid sounds and graphics (Duplantis, MacGregor, Klawe and Ng, 2002; Johnson and Miller, 2002; Kiesler, Sproull and Eccles, 1985; Pearl, Pollack, Riskin, Thomas, Wolf and Wu, 1990). Consequently, girls who do not enjoy this kind of entertainment (Gürer and Camp, 2002) will not gain experience with computers in their childhood and grow up in the belief that computers are "a boys' thing" (Balcita, Carver and Soffa, 2002). Many researchers claim that the fact that, during their childhood and school years, girls do not gain as much experience with computers as boys do is an important factor in discouraging them to be actively involved with computers (Pearl, Pollack, Riskin, Thomas, Wolf and Wu, 1990; Teague, 2000; Klawe, 2002), b) discrimination, within the classroom, as CS teachers rarely interact with female students (Gürer and Camp, 2002; Lazowska, 2002), within the family, for example by placing the family P.C. in the boy's room (Balcita, Carver and Soffa, 2002) and within the working environment (Pearl, Pollack, Riskin, Thomas, Wolf and Wu, 1990; Teague, 2000), c) lack of encouragement in school (Gürer and Camp, 2002) and at home (Countryman, Feldman, Kekelis and Spertus, 2002) in using computers, as they usually viewed as "not suitable for girls", d) limited access to computers or computer games in both schools (Countryman, Feldman, Kekelis and Spertus, 2002; Jepson and Perl, 2002), as boys tend to dominate in computer laboratories (Gürer and Camp, 2002), and video arcades (Kiesler, Sproull and Eccles, 1985), e) the hostile and uncomfortable atmosphere usually created by boys when they participate in computing activities (Gürer and Camp, 2002).

The social environment also negatively affect women about CS&E: a) the media contribute to the formation of a CS stereotype (Fisher and Margolis, 2002; Jepson and Perl, 2002; Klawe, 2002): men more than women are presented using computers (Cohoon, 2002; Duplantis, MacGregor, Klawe and Ng, 2002; Johnson and Miller, 2002; Lazowska, 2002), usually appearing to be myopically focused on their P.C. and lacking in other social interests (Klawe, 2002). In addition, a negative impression is promulgated through the media concerning the demands of a job in the Computer Science Industry (Gürer and Camp, 2002), work isolation and the long and stressful working hours (Duplantis, MacGregor, Klawe and Ng, 2002; Lazowska, 2002). These are characteristics that women do not appreciate when choosing studies or a career. b) the lack of successful women as mentors and role models in the field of CS, all levels of education, the Computer Science Industry and society in general, has a negative psychological effect on some women during the course of their studies, often leading them to drop out (Balcita, Carver and Soffa, 2002; Lazowska, 2002; Pearl, Pollack, Riskin, Thomas, Wolf and Wu, 1990). Moreover, the male-dominated world of Academia (at least in terms of CS Departments) appears to be blocking women from continuing their studies at a doctoral or even postgraduate level (Cohoon, 2002; Gürer and Camp, 2002; Lazowska, 2002).

Women also have different potential job expectations that conflict with their beliefs of what a Computer Science job entails (Clayton and Lynch, 2002; Craig, Paradis and Turner, 2002; Duplantis, MacGregor, Klawe and Ng, 2002; Jepson and Perl, 2002). Additionally, their priorities are quite different from those of men, who are not so greatly concerned about creating a family as they are about their career and professional progress (Jepson and Perl, 2002; Pearl, Pollack, Riskin, Thomas, Wolf and Wu, 1990; Teague, 2000).

With the above in mind, it is clearly important to determine if achievement in CS&E is affected by gender differentiation. Despite the fact that many researchers focus on the specific reasons that cause women's low participation in CS, surveys on the relationship between gender and achievement in CS&E have not yet been reported. The aim of this article is to investigate: a) the analogy of diplomas between male and female graduate students in CS&E, b) the relationship between gender and achievement in CS&E, and c) the relationship between gender and the duration of the study of graduate students. Such an investigation has not yet been reported.

The article is organised as follows: "The Context of the Study" presents details about the way the research was conducted, referring to the study sample and the methodology followed; "The Results" gives a full description of the upcoming results of the research, illustrated with pertinent diagrams; the "Discussion" section, where the findings are discussed under the view of theoretical framework. Overall conclusions of the article are summarized in the "Conclusion" section.

2. THE CONTEXT OF THE STUDY

This study focuses on the relation between gender differences and achievement in CS&E. The study was conducted in the Computer Engineering and Informatics Department, University of Patras, Greece. CEID is the oldest department regarding CS&E in Greece and it has a 25-year life. One thousand ninety hundred and fifty five (1957) diplomas of graduate students of the previously mentioned department were studied in terms of gender and: a) diplomas taken, b) achievement in terms of grading and c) duration of studies in CEID. The sample of diplomas used regarded all graduated students of CEID, from June 1985 since April 2005 (21 years in total). The data was statistically processed using MS-Excel.

3. RESULTS

3.1. Gender and diplomas regarding CS&E taken at CEID

The number of students graduated each year during the last 21 years of CEID is presented in Table 1 (column 2). This Table also shows the number of female and male students graduated these years (column 3 and column 4 correspondingly). The percentages of female/male graduated students per year are also presented in column 5 and column 6 correspondingly. The last column of Table 1 shows the ratio of female/male graduate students per year. The penultimate row of this Table demonstrates the total number of students graduated during the last 21 years of CEID, the total number of female and male graduates as well as the total percentage of female and male graduated students. The last row of Table 1 presents the average of students of both gender, as well as the average of female and male graduated, and the average of ratio of female/male graduates.

Table 1. Gender and graduation during a 21- year period in CEID

Year of Graduation	Number of Graduated			Percentage of Graduated		Female/Male
	Students	Female	Male	Female (%)	Male (%)	
1985	31	11	20	35,48	64,52	0,55
1986	40	13	27	32,50	67,50	0,48
1987	42	8	34	19,05	80,95	0,24
1988	73	16	57	21,92	78,08	0,28
1989	131	34	97	25,95	74,05	0,35
1990	118	29	89	24,58	75,42	0,33
1991	101	31	70	30,69	69,31	0,44
1992	84	18	66	21,43	78,57	0,27
1993	119	26	93	21,85	78,15	0,28
1994	105	19	86	18,10	81,90	0,22
1995	101	24	77	23,76	76,24	0,31
1996	108	21	87	19,44	80,56	0,24
1997	120	30	90	25,00	75,00	0,33
1998	99	17	82	17,17	82,83	0,21
1999	101	19	82	18,81	81,19	0,23
2000	76	20	56	26,32	73,68	0,36
2001	106	28	78	26,42	73,58	0,36
2002	114	26	88	22,81	77,19	0,30
2003	129	21	108	16,28	83,72	0,19
2004	130	30	100	23,08	76,92	0,30
2005	29	5	24	17,24	82,76	0,21
Total	**1957**	**446**	**1511**			
Average	**93,19**	**21,24**	**71,95**	**22,79**	**77,21**	**0,30**

As it is shown in Table 1, the average of graduate students during the last 21 years at CEID is 93.19 graduates per year. The average of female graduate students during these years is 21.24 while the average of male graduate students is 71.95. Consequently, during this 21-year period of time, the average of ratio of male/female graduate students is 0.3 which means that male students are about 3 times more than female ones.

3.2. Gender and achievement

The average achievement as it reflected in the diploma's degrees of graduate students per year is presented in Table 2. In particular, the average achievement of female graduates per year is presented in column 2 and column 5. In addition, the average achievement of male graduates per year is presented in column 3 and column 6.

Table 2. Gender and achievement

Graduated Year	Average achievement in the diploma's degrees		Graduated Year	Average achievement in the diploma's degrees	
	Female	Male		Female	Male
1985	7,56	7,70	**1996**	7,90	8,04
1986	7,51	7,37	**1997**	7,82	8,09
1987	7,66	7,64	**1998**	7,91	7,94
1988	7,57	7,76	**1999**	7,99	7,93
1989	7,89	7,92	**2000**	7,92	7,96
1990	7,92	8,16	**2001**	7,74	7,80
1991	8,17	8,04	**2002**	7,62	7,66
1992	8,13	8,23	**2003**	7,87	7,71
1993	8,07	7,97	**2004**	7,47	7,54
1994	8,01	8,03	**2005**	7,50	7,38
1995	8,06	8,08			
Average				**7,85**	**7,89**

Regarding achievement, as it is shown in Table 2, no significant differences exist between graduates of opposite gender during the 21-year of graduation at CEID.

Table 3 presents a classification of graduates in terms of their diploma's degrees. This classification used by all Universities in Greece. The total number of graduates included in each category is presented in column 5 of this Table while the numbers of female and male graduates included in these categories are presented in column 3 and column 4 correspondingly. In column 6 and column 7 the percentages of female and male graduates regarding each category are also demonstrated.

As it is shown in Table 3 the percentage of female diplomas classified as "very good" is higher than the average female-graduates (22.9) while the percentage of female-diplomas classified as "excellent" is less than this average. In contrast, the percentages of male diplomas classified as "excellent" and "good" are less that the average of male-graduates (77.21).

Table 3. Gender and classification of graduates in terms of their diploma's degrees

Achievement	Degree	Number		Total Students	Percentage (%)	
		Female	Male		Female	Male
Excellent	8.5 - 10.00	62	310	372	16,67	83,33
Very Good	7.5 - 8.49	262	778	1040	25,19	74,81
	6.5 - 7.49	121	404	525	23,05	76,95
Good	5.5 - 6.49	1	19	20	5,00	95,00

Table 4 presents a classification of graduates of the same gender based on their diploma's degrees. The criteria used for this classification are same with the previously mentioned ones. The number of female-graduates included in each category is presented in column 3 while the number of male graduates classified in each category is also presented in column 5 of this Table. Corresponding percentages are demonstrated in column 4 and column 6 of this Table. In Table 4 one can see that regarding with the "excellent" category, the percentage of male graduates (20.52%) is higher than the percentage of female graduates (13.90%). The percentage of female graduates characterized as "very good" is higher (85.87%) than the percentage of male graduates in this category (78.23%). On the whole, no significant gender differences exist regarding with achievement.

Table 4. Gender and classification of graduates of the same gender in terms of their diploma's degrees

Achievement	Degree	Female		Male	
		Number	Percentage (%)	Number	Percentage (%)
Excellent	8.5 - 10.00	62	13,90	310	20,52
Very Good	7.5 - 8.49	262	58,74	778	51,49
	6.5 - 7.49	121	27,13	404	26,74
Good	5.5 - 6.49	1	0,22	19	1,26

Table 5 presents the gender of the first five graduates in terms of their diploma's degree. For example in the third row of this Table one can see that at graduated year 1985, the gender of the first, second and third graduate (see column 2, column 3 and column 4) was Male (M) while the gender of fourth and fifth graduate (see column 5 and column 6) was female (F).

Table 5. Gender of the first five graduates at CEID

Graduated Year	Gender of the first five graduates at CEID				
	First	Second	Third	Fourth	Fifth
1985	M	M	M	**F**	**F**
1986	**F**	M	**F**	M	M
1987	M	M	M	**F**	M
1988	M	M	M	M	M
1989	M	M	M	M	**F**
1990	M	**F**	M	M	M
1991	M	M	**F**	M	**F**
1992	M	M	M	**F**	M
1993	M	**F**	M	M	M
1994	M	M	M	M	M
1995	M	M	M	M	M
1996	M	M	M	M	M
1997	M	M	M	M	M
1998	M	M	M	M	M
1999	M	M	**F**	M	**F**
2000	M	M	M	**F**	M
2001	M	M	M	M	M
2002	**F**	M	M	M	M
2003	M	M	M	**F**	M
2004	M	M	M	M	M
2005	M	M	**F**	M	M

As it is shown in Table 5: in the position of first and second graduate, including 21 graduates for each position there were 2 women (9.5%) and 19 men 19 (90.5%). In the position of third and fifth graduate,

among 21 graduates also for each position, there were 4 women (19.05%) and 17 men (80.95%). In forth position among 21 graduates there are 5 women (23.8%) and 16 men (76.2%).

It is worth noting that the percentage of women achieving a first and a second position in their class is lower than the average of female-graduates (22.9) while the percentage of women achieving a third to a fifth positions is very close to this average.

3.3. Gender and duration of undergraduate studies

Table 6 presents the average of duration of undergraduate studies regarding the students graduated during 21 years of graduation at CEID. In the table, the opposite genders distinguish in columns 2 and 5 for female and columns 3 and 6 for male students, correspondingly. The columns 1 and 4 stand for the graduate year.

Table 6. Gender and duration of studies in terms of years spend to obtain a diploma at CEID

Graduated Year	Average Duration of Studies per year in terms of years spend to obtain a diploma at CEID		Graduated Year	Average Duration of Studies per year in terms of years spend to obtain a diploma at CEID	
	Female	Male		Female	Male
1985	5,68	5,48	**1996**	5,82	6,09
1986	5,65	5,73	**1997**	6,46	6,11
1987	5,74	6,00	**1998**	5,90	6,10
1988	5,76	5,95	**1999**	5,72	5,98
1989	5,58	5,76	**2000**	5,75	6,20
1990	5,92	5,87	**2001**	5,91	6,34
1991	5,61	6,00	**2002**	7,32	6,61
1992	5,73	6,02	**2003**	5,82	6,75
1993	5,88	6,47	**2004**	5,73	6,10
1994	5,93	6,17	**2005**	6,27	6,13
1995	5,95	6,06			
Average duration of undergraduate studies during 21-years of graduation at CEID				**5,92**	**6,14**

As it is shown in this Table (last row) the average duration regarding with the undergraduate studies of female students (5.92 years) is less than the duration of the corresponding studies of male students (6.14 years) at CEID.

4. DISCUSSION

Gender and diplomas in CS&E at CEID. A number of factors referred to in the literature well documented that women are under-representation in actively involving with computers in general as well as in involving with studies regarding with Computer Science and Engineering (Galpin, 2002; Gürer and Camp, 2002). The general idea that women are under-represented in CS&E is also supported by the data presented in this paper: the average percentage of female diplomas taken at the Computer Engineering and Informatics, University of Patras, Greece during a 21-year period of graduation is 22.79%. However, this participation percentage is higher than the lower percentages (10%) and less than the higher percentages (40%) referred to similar diplomas taken at Universities in other countries. It is worth to note that, regarding a sample of twenty three Universities and Institutes from thirteen European countries (Galpin, 2002), the percentage of female-diplomas in CEID is occupied the 8th position. This percentage is also higher than the percentages referred from USA and Canada (20.4%).

It is also important to mention that the ratio of female/male diplomas is higher (0.52) in the early two years of graduation at CEID than in the last two (0.25) years of graduation. In our view, this is explained by the fact that in these early years: a) the CS&E profession was new and attractive for candidate students in

Greece and CEID was the only department in this profession while nowadays there 20 departments, b) women probably imagined CS&E as a very attractive profession but they were unaware about its real characteristics such as: working in isolation, as well as the long and stressful working hours in CS and Informatics Industry. These characteristics are different from the reported women potential job expectations.

Gender and achievement at CEID. The average degree of female diplomas during the 21-year graduation at CEID is 7.85 while the corresponding average of male diplomas is 7.89. The majority of both male and female diplomas were classified as "very good" (6.5-8.5 points). The percentage of female-diplomas classified as "excellent" (8.5-10 points) is less than the average female-graduates (22.9) while the percentage of those diplomas characterized as "very good" is higher than this average. In contrast, the percentages of male diplomas classified as "excellent" and "good" (5.5-6.5 points) are less than the average of male-graduates (77.21). Regarding with the "excellent" category, the percentage of male graduates (20.52%) is higher than the percentage of female graduates (13.90%). The percentage of female graduates characterized as "very good" is higher (85.87%) than the percentage of male graduate in this category (78.23%). In the position of first and second graduate student, during the 21-year graduation at CEID, there were 2 women (9.5%) and 19 men (90.5%). In the position of third and fifth graduate student, during this period of time there were 4 women (19.05%) and 17 men (80.95%). In the forth position there were 5 women (23.8%) and 16 men (76.2%). It is worth noting that the percentage of women achieved a first and a second position in their class is lower than the average of female-graduates (22.9), while the percentage of women achieved a third to a fifth positions is very close to this average. On the whole, no significant gender differences exist regarding achievement in CS&E.

Gender and duration of undergraduate studies at CEID. The average duration regarding with the undergraduate studies of female students at CEID is less than the duration of the corresponding studies of male students.

5. CONCLUSIONS

Gender differences, participation and achievement regarding Computer Science and Engineering have been investigated in this study. In particular, 1957 diplomas of graduate Computer Engineers from the Computer Engineering and Informatics, University of Patras, Greece were studied. The analysis of the data showed that women are under-represented in this department. More specifically, the analysis of the data demonstrated that during 21 years of graduation at CEID: male graduated students were three times more than the female ones. Regarding achievement; no significant differences exist between male and female graduate computer engineers. However, female students complete their studies earlier than their male colleagues.

More research is needed to investigate if a specific gendered profile can be formed taking into account both: gender different preferences regarding with the variety of subjects included in CS&E as well as gender different strengths and weaknesses related to these subjects.

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