ACHIEVEMENTS IN COMPUTER SCIENCE COURSES: GENDER ISSUES

Ioannis Berdousis, Maria Kordaki

Dept of Cultural Technology and Communications, University of the Aegean (GREECE)

Abstract

The aim of this study is to investigate the relationship between gender and achievement in the various subjects of CS. For this reason, the degrees (89 degrees) of all graduate students who enrolled from 2002 to 2008 (a 6-year period of graduation) at the Department of CS and Technology, University of Peloponnese, Greece were studied. To this end, the grades of these students in both; compulsory courses and electives were studied and quantitatively analysed. These courses are grouped into: compulsory courses and electives of the "Theoretical Computer Science" (TCS) division, compulsory courses of "Mathematics & Physics" (M&P) and electives of "General Education" (GE) that cover a wide range of subjects that can be applied to many different careers and students can choose them according to their interests. In terms of methodology this study can be characterized as a case study. The analysis of the data shows, that: (a) male students have slightly better, or even, mean grades in all of the mandatory courses in TSC division and in most of M&P compulsory courses, (b) both male and female students have low mean grades in compulsory "Mathematics" courses (mean grades<7,5), (c) female students have better mean grades in most of the electives in TCS division and GE, (d) in the aforementioned courses, female students have more "excellent" mean grades (grade >=8,5) than male students, and (e) there is a tendency for female students to perform slightly better than male students in those courses which are chosen by more female students.

Keywords: Computer Science, achievements, courses, gender.

1 INTRODUCTION

Women are underrepresented in all fields of Computer Science: undergraduate and graduate studies, the Computing Industry and the Computing Academic Sector [6, 10, 12, 17]. The female-male ratio for those involved in Computing shrinks dramatically from early student years to working years. This phenomenon, known as "the pipeline shrinkage problem" is complex and multi-faced, but well known and documented [10, 15]. Statistics tell us that women are largely underrepresented in all Computing careers, be they academic or within the industry [10]. Despite the fact that many remarkable women have made their mark in the history of Computing through their great achievements [11], female computer scientists are treated as inferior and many believe that is more natural for men than women to study computing and work in the Computing Industry.

Studies over the past two decades have shown that there are numerous factors contributing to the fact that females have a lower participation rate in Computer Science (CS) than males and that some aspects about Computing may discourage females [6]. Some of these studies attempted to suggest appropriate actions to increase the number of females studying Computing, and eventually increase the number of females involved in the Computing Industry. It is stated, that females lose interest in CS early on in their life, as girls don't gain as much experience with computers as boys do during their childhood and at school [16]. Back to their early years, the male orientation of computer games seems to be a crucial factor contributing to this discouragement [8]. At school, boys often tend to monopolize instructors' time, leaving the girls to try and figure things out on their own. Moreover, more boys are positive and more girls are negative towards computers. There are studies that have shown that positive attitudes towards CS can greatly influence the success of a student and whether he or she continues in CS [19]. Females have less confidence in their abilities and individual accomplishments than males do, despite the fact that they often perform at the same levels [13], and report feeling "out of place" in the male-dominated, computing culture. Females tend to avoid CS because of the "tinkering" aspect of the field, in spite of being attracted to the mathematical and logical aspects of computing. Even though they perform at the same levels, women have less confidence in their abilities and individual accomplishments than men [18].

What is more, discrimination both within the classroom and within the family, limited access to computers both at school and at home and the hostile and uncomfortable environment created by

boys when participating in computing activities or male partners appear to be harmful factors, causing low self-confidence [10]. Women and men have different levels of motivation in pursuing a CS career, and their communication styles often differ, as women are often less aggressive than men in promoting themselves, attempting new or challenging activities, and pursuing awards or fellowships. It is also stated, that family support plays a critical role in choice of CS as a subject of their studies and consequentially as a career pathway. Parents socialize their children based on gender stereotypes, unintentionally providing obstacles for their own daughters. This can cause lack of self-esteem and without self-confidence it is almost impossible to experience new and supposedly “difficult” things, such as the CS discipline [18]. Moreover, one of the biggest turn-offs is the "geek factor": High School girls often envisage a career in Computing as a lifetime spent in an isolated cubicle writing code. Computer programmers depicted in popular media are overwhelmingly male, contributing to an absence of role models for would-be female computer programmers. Media has a strong influence on girls' impression of CS, forming a computing stereotype where men, more than women, are represented using computing for hours and lacking in other social interests.

As far as the world of Academia is concerned, in terms of Computing Departments, it is a male-dominated, so non-women-friendly environment. Women are not encouraged to pursuit a doctoral or at least continue their studies at a postgraduate level. This lack of women in the field of research has a negative psychological effect on some women during their studies [3]. A successful woman in computing research, the computing industry and society in general, can act as a role model and could contribute in many extremely valuable ways to the mentoring of young, female computer scientists [9].

Despite the barriers, females are willing to participate in CS as long as they feel that their involvement is meaningful and relates to social contribution [5]. They prefer to apply the knowledge they acquire in order to produce something useful. They view the computer as a tool for use within a larger societal and/or interdisciplinary context [7]. Recent research has shown that, as far as undergraduate studies in CS are concerned, females appear to choose courses that belong to the theoretical division of computing, while a higher percentage of males choose courses that belong to the Software Systems division of computing [14]. Both genders appear to choose courses from the Computer Technology division of computing [14] in equal numbers. However, females tend to believe that they lack the skill set needed to be successful in the field of computing [2], skills which are obtained primarily in undergraduate studies, where male and female students follow the curriculum attending compulsory courses and selected electives.

With the above in mind, it is clearly important to determine if achievements in CS courses are affected by gender differentiation and connected to the selection made by male and female students. This is the aim of this study. Here, it is worth noting that, recently, we have investigated the relationship between gender and achievement in some subjects of CS and especially in the courses fall in the divisions “Computer Technology and Computer Systems” and “Software Systems”. This study, pointed out, that male students have slightly better grades in most of the compulsory courses in those divisions, but in some of the electives, female students have better average grades than their counterparts. Some core hardware/ lab-based software courses are also not selected by females, and in those courses which are chosen by the majority of females, there is a tendency for them, to perform slightly better than males and to perform “Excellent” in higher percentage [1]. Thus, the aim of this study is to investigate, the relationship between gender and achievement in other aspects of CS, beyond computer technology and software systems. This article is organized as follows: Section 2 presents details about the manner in which the research was conducted, referring to the study sample and the methodology followed; Section 3 gives a full description of the research findings; overall conclusions are summarized in Section 4, while, overall conclusions are summarized in “Conclusion”.

2 THE CONTEXT OF THE STUDY

This study focuses on the investigation of the relationship between gender and achievement in various CS subjects. For this reason, 89 degrees covering a 6-year period of graduation at the Department of Computer Science and Technology, University of Peloponnese, Greece, were studied. In fact, the study contains the degrees of all graduate students who enrolled from 2002 to 2008. The grades of these students in both compulsory courses and electives were studied and quantitatively analysed. These courses are classified into 4 divisions, namely: “Computer Technology and Computer Systems”, “Software Systems”, “Theoretical Computer Science” and “General Education”. This study examines, the relationship between gender and achievement in: “Theoretical Computer Science” (TCS) division, “General Education” (GE) electives and “Mathematics & Physics” (M&P) compulsory

courses. TCS has 3 compulsory courses and 11 electives, while GE electives are 21 and M&P compulsory courses are 7. In terms of methodology, this study can be characterized as a case study [4].

3 RESULTS

This section gives a full description of the research findings. The number of male graduates is 69, and the number of females is 20. As far as the compulsory courses of TCS division and M&P are concerned, the Tables which are presented below are divided into 2 sections: males and females per course. Each section is organized as follows: the mean grade of the course (first column) and the standard deviation (STD) (second column). As far as the electives are concerned, the Tables are organized as described above, with one exception: there is one more column per section presenting the percentage of males/females that chose the course. The Tables are sorted in ascending order of the mean grades of the female students.

3.1 Students' Choices and Achievements in "Theoretical Computer Science" (TCS) courses

Table 1 presents the achievements of male and female students in terms of the compulsory TCS courses. As is shown in Table 1, male students have slightly better mean grades in 2 out of the 3 compulsory CTCS division courses. The standard deviation (std. deviation) in each course is low, pointing to grades of all students not being widely dispersed around the mean grade.

Table 1. Achievements in "Theoretical Computer Science" (TCS) compulsory courses.

Courses	Male		Female	
	Mean grade	STD	Mean grade	STD
Theory of Computation	6,9	0,94	6,9	1,02
Introduction to the Science & Technology of Informatics	7,8	0,98	7,25	0,93
Computational Science I	8,33	1,15	8,1	1,01

In "Introduction to the Science & Technology of Informatics" male students have mean grade 7,8 with a std. deviation of 0,98 while female students have mean grade 7,25 with a std. deviation of 0,93. In "Computer Science I" male students have mean grade 8,33 with a std. deviation of 1,15 while female students have mean grade 8,1 with a std. deviation of 1,01. In "Theory of Computation" male and female students have the same mean grades but different std. deviation. The std. deviation in that course is lower for male students, pointing to grades of those students not being widely dispersed around the mean grade. Overall, from Table 1, one can see that male students have slightly better, or even, mean grades in all of the mandatory courses in TSC division. Even if male students have slightly better mean grades in all compulsory courses, female students perform more or less as well.

Table 2 presents the choices and the achievements of male and female students in terms of the TCS electives courses. As shown in Table 2, male students have a mean grade greater than 8,5 in 3 TCS electives: "Advanced Topics in Theoretical CS", "Computational Science II" and "Operational Research". Female students have a mean grade greater than 8,5 in 5 TCS electives: "Advanced Topics in Theoretical CS", "Graph Theory", "Computational Science II", "Operational Research", "Advanced Topics in Theoretical CS". It would seem that those 3 courses where male students have a mean grade greater than 8,5 are a subset of the courses where females have a mean grade greater than 8. Moreover, from the 11 CTS electives, female students have a greater mean grade than male students in 9 courses: "Computational Complexity", "Cryptography", "Parallel Algorithms", "Fractals", "Combinatorial Optimization", "Graph Theory", "Computational Science II", "Operational Research", "Advanced Topics in Theoretical CS". The electives "Operational Research" and "Advanced Topics in Theoretical CS" are selected from one female student who performs excellent "10". It is worth noting that "Computational Science II" is selected from the half of female students (50%) and almost half of the male students (49,28%) and both male and female students perform exceptionally well having mean grade 9,2 and 9,25 respectively.

Table 2. Achievements in "Theoretical Computer Science" (TCS) electives.

Courses	Male			Female		
	Percentage (%) of students who select the course	Mean grade	STD	Percentage (%) of students who select the course	Mean grade	STD
Computational Complexity	24,64	6,91	0,77	**25**	7,1	1,02
Cryptography	14,49	6,6	1,50	**40**	7,5	1,07
Parallel Algorithms	76,81	7,64	1,93	**90**	7,7	1,81
Computational Geometry	36,23	8,06	1,39	**60**	7,88	1,54
Fractals	27,54	7,68	1,31	**35**	8,14	1,49
Combinatorial Optimization	91,30	8,31	1,34	90	8,44	1,28
Advanced Topics in TCS	23,19	**8,88**	1,18	10	**8,5**	0,35
Graph Theory	15,94	6,18	1,53	10	**9,25**	0,35
Computational Science II	49,28	**9,2**	0,87	**50**	**9,25**	0,72
Operational Research	14,49	**9,5**	0,52	5	**10**	-
Advanced Topics in TCS	0	0	-	**5**	**10**	-

Additionally, in Table 2 one can see that, 7 out of the 11 TCS electives have been chosen by a higher percentage of female than by male students, namely: "Computational Complexity", "Computational Science II", "Advanced Topics in Theoretical CS", "Fractals", "Parallel Algorithms", "Computational Geometry", "Cryptography". In 6 of these courses female students have a higher mean grade than males do. It seems that, female students not only choose at a higher percentage than male electives from TCS division but they perform better than male in these courses.

3.2 Students' Choices and Achievements in "Mathematics & Physics" (M&P) courses

Table 3, presents the achievements of male and female students in terms of the compulsory M&P courses.

Table 3. Achievements in "Mathematics & Physics" (M&P) compulsory courses.

Courses	Male		Female	
	Mean grade	STD	Mean grade	STD
Linear Algebra	5,64	1,31	5,55	1,06
Mathematics I	6,6	1,42	5,95	1,27
Mathematics II	6,36	1,57	6	1,61
Probability Theory and Statistics	7,14	1,84	6,45	1,68
Arithmetic Analysis	7,1	0,93	6,6	1,15
Discrete Mathematics	6,2	1,05	6,62	1,06
Physics I	7,28	1,83	7,38	1,89

As it is shown in Table 3, male students have slightly better mean grades in 5 out of the 6 Mathematics courses whereas in "Physics I" female students have slightly better mean grade. Specifically, in "Linear Algebra" male students have mean grade 5,64 with a std. deviation of 1,31 whereas female students have mean grade 5,55 with a std. deviation of 1,06, in "Mathematics I" and in "Mathematics II" male students have mean grades 6,6 with a std. deviation of 1,42 and 6,36 with a std. deviation of 1,57 respectively whereas female students have mean grades 5,95 with a std. deviation of 1,42 and 6 with a std. deviation of 1,61 respectively, in "Probability Theory and Statistics" male students have mean grade 7,14 with a std. deviation of 1,84 whereas female students have mean grade 6,45 with a std. deviation of 1,68, in "Arithmetic Analysis" male students have mean grade 7,1 with a std. deviation of 0,93 whereas female students have mean grade 6,6 with a std. deviation of 1,15. Finally, in "Discrete Mathematics" male students have mean grade 6,2 with a std. deviation of 1,05 whereas female students have mean grade 6,62 with a std. deviation of 1,06 and in "Physics I" male students have mean grade 7,28 with a std. deviation of 1,83 whereas female students have mean grade 7,38 with a std. deviation of 1,89. It seems that both male and female students have low mean grades in all "Mathematics" compulsory courses and in "Physics". The mean grades of both male and female students are far from 8,5 ("Excellent"). It is mentioned that all these 7 courses are compulsory courses for all of the students in order to graduate.

3.3 Students' Choices and Achievements in "General Education" (GE) electives

Table 4, presents the choices and the achievements of male and female students in terms of the GE electives. "General Education" electives cover a wide range of subjects that can be applied to many different careers and students can choose them according to their interests. As is shown in Table 4, male students have a mean grade greater than 8,5 in 5 elective GE courses, namely: "Legal issues in informatics Legal issues in informatics", "Sociology", "Informatics Teaching", "Cognitive Science" and "New product and service development". Female students have a mean grade greater than 8,5 in 11 elective courses in the same division, namely: "Computers and Education", "Banking IT", "Sociology", "Psychology", "Differential Equation", "French", "Informatics Teaching", "Philosophy", "French Terminology", "Cognitive Science" and "New product and service development". 4 of these courses are common for both male and female students. It is worth noting that very few females (in some cases, none at all) choose: "Introduction to the Economic Science I & II", "Game Theory", "Legal issues in informatics", "French" and "New product and service development", whereas the elective course that is not selected from male students is "Introduction to the Economic Science II". A higher percentage of female students, compared to males, seem to choose "Social and Professional Issues", "English Terminology", "Pedagogics", "History of Computers and Communications", "Computers and Education", "Banking IT", "Sociology", "Psychology", "Differential Equation", "Informatics Teaching", "Philosophy", "French Terminology" and "Cognitive Science". In 11 out of those 13 electives female students perform better than male students achieving higher grades. Overall, male students have a higher mean grade in 7 out of the 21 GE electives while female students have a higher mean grade in 12 out of the 21 electives in the same division. There are also 2 electives that both male and female students have almost same mean grades. Female students seem to perform better in "General Education" electives "helping" their degree grade.

Table 4. Achievements in "General Education" (GE) electives.

Courses	Male			Female		
	Percentage (%) of students who select the course	Mean grade	STD	Percentage (%) of students who select the course	Mean grade	STD
Introduction to the Econ. Science I	11,59	7,07	1,39	0	0	-
Introduction to the Econ. Science II	0	0	-	5	5	-
Social and Professional Issues	18,84	8,46	1,20	**25**	5,8	1,10
Game theory	5,80	7,12	1,93	5	6	-
English	92,75	6,6	1,07	80	6,38	1,48
English Terminology	94,20	7,3	1,24	**100**	6,87	1,23

Pedagogics	68,12	7,13	1,74	**90**	7,14	1,53
Management Information Systems	13,04	7,33	1,70	35	7,57	1,90
History of Computers & Communications	73,91	8,06	1,07	**80**	7,81	1,22
Legal issues in informatics	10,14	**9,57**	0,79	5	8	-
Computers and Education	27,54	8,05	1,01	**30**	**8,5**	0,92
Banking IT	11,59	7,62	1,89	**25**	**8,6**	0,82
Sociology	27,54	**8,63**	1,38	**50**	**8,65**	1,89
Psychology	34,76	7,8	1,44	**55**	**8,63**	1,14
Differential Equation	42,03	7,31	1,91	**45**	**8,67**	1,78
French	5,80	8,25	1,11	5	**9**	-
Informatics Teaching	20,29	**8,86**	0,66	**25**	**9**	1,41
Philosophy	14,49	7,1	1,39	**20**	**9,25**	1,54
French Terminology	14,49	8,1	0,99	**15**	**9,33**	0,57
Cognitive Science	11,59	**9**	1,30	**25**	**9,8**	,45
New product and service development	8,70	**9,5**	0,54	5	**10**	-

4 CONCLUSIONS

This study investigated the relationship between gender and achievement in some of the various CS subjects, studying the degrees (89 degrees) earned by the students -during a 6-year period of graduation- at the Department of CS and Technology, University of Peloponnese, Greece. The grades of these students in both; compulsory courses and electives were studied and quantitatively analysed. Those courses are grouped into: compulsory courses and electives of the “Theoretical Computer Science” (TCS) division, compulsory courses of “Mathematics & Physics” (M&P) and electives of “General Education” (GE) that cover a wide range of subjects that can be applied to many different careers and students can choose them according to their interests. The analysis of the data showed that: (a) male students have slightly better, or even, mean grades in all of the mandatory courses in TSC division and most of M&P compulsory courses, (b) both male and female students have low mean grades in compulsory “Mathematics” courses (mean grades<7,5), (c) female students have better mean grades in most of the electives in TCS division and GE, (d) in the aforementioned courses female students have more “excellent” mean grades (grade >=8,5) than male students, and (e) there is a tendency for female students to perform slightly better than male students in those courses which are chosen by more female students.

ACKNOWLEDGEMENTS

We thank the *Eugenides Foundation* for the generous grant in support of our research.

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