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Computing and STEM in Greece: Gender representation of students and teachers during the decade 2002/2012

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Abstract Female student representation in Computing and Science, Technology, Engineering and Mathematics (STEM) Tertiary education is under-researched in a number of countries including Greece, while studies on female secondary level education teacher representation in Computing and STEM have not yet been reported. This study focuses on the investigation of gender representation of tertiary-level education students (freshmen, graduates, master's degree graduates and PhD's) and of secondary-level education teachers in Computing and STEM education during the decade 2002–2012 in Greece. A quantitative study was conducted taking into account appropriate data that emerged from the Hellenic Statistical Authority which is the national statistical service of Greece. During the studied decade:(a) Females were less prevalent than males at all levels of study in Computing and Engineering, (b) the number of males did not exceed that of females in Physics (freshmen, graduates and master's degree holders) or in Mathematics (graduates),(c) Female teachers were less prevalent than males in Computing and STEM,(d) Computing female schoolteachers are better represented at all levels of secondary education compared to the representation of their female counterparts in the rest of the disciplines of STEM education,(e) There is no pipeline shrinkage between female freshmen and graduates of undergraduate studies in Computing and STEM and there was also no female dropout from level (undergraduate studies) to level (master's degree studies) in Greek Computing, Physics and Engineering departments. It seems that the main problem is recruitment and not retention in Computing and STEM, despite female under-representation in most of these disciplines.

Keywords Computing · STEM · Gender · Students · Teachers

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1 Introduction

During the last decade, the number of ICT professionals in the workforce has been steadily increasing around the world and there is no indication that this trend will change in the future (Hüsing et al. 2013). Nevertheless, even with a recent upswing in the number of students taking low-level Computing courses (Camp 2012) it is unlikely that the high demand for employees can be met in the USA or in Europe (Hüsing et al 2013). However, despite the tremendous gains that girls and women have made in education and the workforce during the past 50 years, the dominance in certain scientific and engineering disciplines remains overwhelmingly male (Hill et al 2010). Computing in particular remains a heavily male-dominated field, even after several years of extensive efforts to promote female participation (Cohoon and Aspray 2006). However, if the participation of women in Computing education does not increase, then the growth and the viability of the Computing field will be put in danger (Camp 2012). In fact, women need to be attracted to Computing education not only in order to increase the number of employees in this sector but also to bring diverse experiences to the table (Wolf 2006) since, with a more diverse workforce, scientific and technological products, services and solutions are likely to be better designed and more likely to represent most users (Camp 2012).

To this end, it is worth mentioning that, although they constitute the majority of college students in the USA, women are far less likely than their male peers to plan to major in a STEM field, with one exception - Biological Sciences (Hill et al. 2010). For example, just over one-fifth of male freshmen planned to major in STEM, compared with only about 5 % of female freshmen in 2009 (Hill et al. 2010). In addition, the interest of both female and male college freshmen in majoring in Computing has been following a downward trend (Camp 2012). Furthermore, despite the fact that the proportion of undergraduate degrees awarded to women at university in the USA in all disciplines increased for several decades - reaching a high of 57 % during 2000–2009 - this increase was observed in the percentage of degrees earned by women in all STEM fields except Computing (Camp 2012; Hill et al. 2010). However, despite the fact that women who enter STEM majors in college tend to be well-qualified (Brainard and Carlin 1998; Solis and Hall 2009; Vogt, Hocevar and Hagedorn 2007), many of these academically-capable women leave STEM majors early in their college careers (Ohland et al. 2008). Female representation among doctoral degree recipients in STEM fields has also improved in the last 40 years, but it still remains lower than 30 % in environmental sciences, chemistry, and math, and lower than 20 % in Computing, engineering, and physics (Camp 2012; Kaminski and Geisler, 2012).

The Internet was also used mostly by men in its early days, because text–based communication was used (Weiser 2000; Guadagno and Cialdini 2002). However, since social networking became widespread on the Internet and other forms of mediated communication continue to become ever more popular, we have seen a higher increase in women online, with women more likely than men to use social networking sites such as facebook, twitter and pinterest (Taylor 2009; Mazman and Usluel 2011; Kimbrough et al. 2013). Thus, it would appear worthwhile to investigate whether the increase in women's participation in online computer-mediated communication during the last decade is also accompanied by an increase in women's participation (as students) in Computing education at Tertiary level during this decade.

Numerous factors that contribute to women's low participation in Computing have been mentioned in various studies over the past two decades (Gürer and Camp 2002; Margolis and Fisher 2003; Cohoon and Aspray 2006; Ladner and VanDeGrift 2011). Girls appear to lose interest in Computing early on, as they fail to gain as much experience with computers as boys do during their childhood and at school. Usually, the first experience boys and girls have with computers is through computer games, which are designed with boys - not girls - in mind (Denner et al 2012). At school, boys tend to monopolize the instructors' time, often leaving girls frustrated and trying to figure things out independently. Computing courses also have a reputation for being boring and not providing students with freedom and creativity (Rich et al 2004). As a result, most women have significantly less interest, less hands-on experience and less confidence with Computing than most men (Margolis and Fisher 2002). Loss of self-confidence impacts women more than men and is a major cause for women leaving Computing at all levels in the pipeline (Gürer and Camp, 2001). Moreover, a greater percentage of boys than girls hold positive attitudes towards Computing while more girls have negative attitudes (Sax et al 2010). Studies indicate that, regarding Computing tasks, females are more risk averse than men, avoiding Computing because of the 'tinkering' aspect of the field, in spite of being attracted to its mathematical and logical aspects (Beckwith et al. 2006). However, studies have shown that, once women enter a Computing department, they actually perform as well as men (Ilias and Kordaki 2006), prefer a diversity of Computing courses (Kordaki and Berdousis 2013) and perform better than men in those courses which are of their choice (Berdousis and Kordaki 2015).

Women also do not usually receive the same level of support as men do from their social environment to enter and remain in the Computing field (Cohoon 2002). Unfortunately, most of the images from parents, teachers, and the media combine to form a Computing stereotype where men, more than women, are represented using computers for hours on end and lacking other social interests, implying that Computing is really for men only (Beyer et al. 2003; Margolis and Fisher 2003). This stereotype is more negative for women than for men. In addition, most young girls have rarely been exposed to a true Computing class with a computing scientist female role model (Townsend 2002). In fact, school teachers (Lunenberg et al 2007) - and especially female Computing teachers with a genuine and sincere manner - can inspire, encourage and help female students to realize their potential and feel confident and capable of succeeding and discovering their own connection with Computing. When young women think about Computing as a career choice, the presence of successful women in Computing is an encouraging signal. It would appear to make sense that a certain level of comfort may be achieved between a young female student and an accomplished female professor; however, if this is so, and female Computing schoolteachers could become ideal female student mentors, this begs the question: Are there enough of them?

To the best of our knowledge, studies on female secondary level education teacher representation in Computing have not yet been reported. Female student representation in Computing is also under-researched in a number of countries including Greece. Thus, it would appear worthwhile to investigate gender representation during the last decade in Greece, in terms of: (a) students in Computing education in comparison with those in the remaining fields of STEM education, and (b) secondary level education

Computing teachers in comparison with those in the remaining fields of STEM education. Such a study has not yet been reported.

The article is organized as follows: The context of the study presents details about the research questions, the data presented in this paper, and the data analysis, the 'Results' section gives a full description of the research findings, followed by a discussion of the results and drawing of conclusions.

2 The context of the study

2.1 Aim of the study and research questions

The aim of this study is to investigate gender representation of students and teachers in Computing and STEM education in Greece during the decade 2002/2012. To approach this aim, in this study, an attempt has been made to answer the following research questions:

- What is the gender representation of students in Computing and STEM education during the decade 2002–2012 in Greece, in terms of: undergraduate studies (freshmen, graduates) and graduate studies (Master's Degree, PhD)
- What is the comparison of female student representation in Computing with the female student representation in related STEM education disciplines
- What is the gender representation of secondary level education teachers during the decade 2003–2013 in Greece in Computing and within related STEM education disciplines
- What is the comparison of female secondary level education Computing teacher representation with the female teacher representation in related STEM education disciplines.

The data collected to answer the aforementioned questions are presented in Sections 3.1., 3.2., 3.3.and 3.4 correspondingly.

2.2 Data

The data presented in this study have been taken from the Hellenic Statistical Authority (EL.STAT) that is the national statistical service of Greece (http://www.statistics.gr/).

The data concerning student representation was classified for every year of the decade - by the authors - into the following disciplines of Computing and STEM education, taking into account the International Standard Classification of Education (ISCED) developed by UNESCO:

- *Computing* = Computer Science & Computer Engineering (including 14 Computing University departments and 8 Electrical & Computer Engineering Schools)
- *Bio/Env* = Biological Sciences and environment (including 7 University departments covering Biology, Genetics and Marine Sciences)
- *Phys* = Physical Sciences (including 14 University departments covering Physics, Chemistry, Geology and Material Sciences)

- *Math* = Mathematics and Statistics (including 10 University departments covering Mathematics, Applied Mathematics and Statistics)
- *Eng* = Engineering (including 18 University departments covering chemical, mechanical and other engineering-related technologies)

The data concerning schoolteacher representation in Computing and STEM secondary education was classified by EL.STAT, for every year of the decade, into the following levels: Gymnasium, General Lyceum and Professional Lyceum. Here, it is worth noting that, Greek secondary education comprises two levels: (a) Gymnasium (variously translated as Middle or Junior High School), a compulsory three-year school, and (b) Lyceum, a three-year, post-Gymnasium, non-compulsory high school; students may choose to attend one of the following different types: (i) General Lyceum (GL)- which is academically oriented, and (ii) technical vocational (or Professional) Lyceum (PL)- which is technically oriented. Computing and STEM disciplines are included in the Greek secondary student curricula and Computing and STEM schoolteachers teach in both of the aforementioned levels of education.

The data regarding students and graduates cover the period from the end of 2002/03 to the end of 2011/12, while the data regarding schoolteachers cover the period from the beginning of 2003/04 to the end of 2012/13. In actuality, the same period of time is studied, as the end of an academic year coincides with the beginning of the next academic year.

2.3 Data analysis and methodology

As regards student representation, EL.STAT presents the total number of students and the number of women each year per department in terms of different categories of students, namely: freshmen, graduates, master's degree graduates and PhD students. In the context of this study, these raw data were processed so that provide information about the number of students and the percentages of females, in all Greek Universities, for each year of the decade, and for each discipline (Computing, STEM and 'Overall') as well as for each student-category (freshmen, graduates, master's degree graduates and PhD students). Thus, the following calculations were realized: (a) the total numbers of students –in all Greek Universities- were added for each year/discipline/student-category, and organized in Tables which are presented in the 'Results' section of this paper, (b) the percentages of female students –in all Greek Universities- for each year/discipline/student-category were also calculated and are presented in these Tables. The Mean (M) and the Standard Deviation (SD) of the percentage of females (F%) were also calculated for the whole decade and are also presented in the last row of the aforementioned Tables.

As far as teacher representation is concerned, EL.STAT presents the total number of teachers and the number of women-teachers -in Greece- each year per discipline, in terms of different levels of education, namely: Gymnasium, Lyceum and Professional Lyceum. Based on these raw data, (a) the percentages of female teachers for each year/discipline/level of education were calculated and organized in Tables which are also presented in the 'Results' section of this paper. (b) The Mean (M) and the Standard Deviation (SD) of the percentage of females (F%) were also calculated for the whole decade and are also presented in the last row of these Tables. In terms of methodology,

this study can be characterized as quantitative research and a case study (Cohen, Manion and Morisson 2007). The SPSS (Version 20) Statistical Analysis Software was used for the data analysis. Due to the fact that, this study refers to the whole population of students and schoolteachers in Greece during the studied decade descriptive statistics was appropriate to be used because there is no need to use inferential statistics in order to generalize the findings of the study.

3 Results

The results that emerged from the data analysis concern the last decade (2002/03 to the end of 2011/12 for students and graduates and 2003/04–2012/13 for schoolteachers) and are presented here in terms of: (1) Gender representation of students in Computing and in STEM education in Greece, (2) Comparison of female student representation in Computing and in the remaining fields of STEM education in Greece, (3) Gender representation of teachers in Computing and in STEM in Greek Secondary Education, and (4) Comparison of female teacher representation in Computing and in the remaining fields of STEM education in Greece.

3.1 Gender representation of students in computing and in STEM education in Greece: 2002/03–2011/12

The total number (N) – male and female - and the percentage of female (F) freshmen in the decade 2002–2012, as well as the total number of degrees (NoD) (Bachelors, Masters and PhDs) and the percentage of those degrees that were awarded to females (F %), during this period of time are demonstrated in Tables 1, 2 and 3 in respect to all Greek: (a) Universities and Engineering Schools (Overall), and Computing Departments (in Table **1**), (b) Bio/Env and Phys Departments (in Table 2), and (c) Math and Eng Departments (in Table 3). The number and the percentage of freshmen and of graduate students is calculated at the end of each academic year. The Mean (M) and the Standard Deviation (SD) of the percentage of females (F%) are also presented in the last row of these Tables.

Overall: As can be seen from Table 1, in every single year of the aforementioned decade females are more prevalent than males in 3 categories: freshmen, graduates of undergraduate studies and graduates of Master's programs with a percentage of over 52 % (see Table 1; columns, 3, 5 and 7). The percentage of female freshmen varies from 59.30 to 61.80 % (see Table 1; column, 3), the percentage of female graduates varies from 62.99 to 64.97 % (see Table 1; column, 5), while the percentage of female Master's Degree graduates varies from 54.05 to 61.63 % (see Table 1; column, 7). However, there are fewer female than male graduates of PhDs every single year in the particular decade, their percentage varying from 27.94 to 43.86 % (see Table 1; column, 9). In total, of the 410,085 freshmen, 60.53 % (SD = 0.81) were female, while of a total of 313,332 Bachelor's degree graduates, 69,170 master's degree graduates, and 15,666 PhD students at all Greek Universities and Engineering Schools during this decade, 64.33 % (SD = 0.58), 57.37 % (SD = 2.37) and 38.78 % (SD = 4.22) were female, respectively (see

Table 1 Gender representation of students in Greek Tertiary Education: Overall and Computing; 2002–2012

Gender Representation of students in Greek Tertiary Education, 2002–2012: Overall and Computing

End of Academic Year	Overall								Computing							
	Freshmen		Graduates		Master		PhD		Freshmen		Graduates		Master		PhD	
	N	F %	NoD	F %	NoD	F %	NoD	F %	N	F %	NoD	F %	NoD	F %	NoD	F %
2002/2003	39,856	59.87	28,565	**62.99**	4041	**54.05**	1001	37.06	2986	30.84	1335	27.87	251	35.06	95	**9.47**
2003/2004	39,508	59.71	28,113	64.00	4283	57.34	949	34.98	3183	**30.85**	1432	**22.63**	216	27.31	136	12.50
2004/2005	40,455	60.25	34,489	64.29	5425	52.35	1589	**27.94**	3390	28.94	1652	27.60	544	28.68	759	13.97
2005/2006	40,479	61.68	32,781	64.33	6191	58.97	1187	40.35	3334	29.96	1732	30.08	238	**25.63**	74	14.86
2006/2007	39,678	**61.80**	29,483	64.81	7067	57.11	2436	39.94	3263	26.60	1644	31.87	300	32.33	117	12.82
2007/2008	39,772	61.35	33,719	64.83	7578	56.36	1404	38.96	3126	24.82	1995	32.98	809	33.37	143	17.48
2008/2009	41,755	61.42	31,353	64.85	8352	56.02	1797	41.07	3185	24.90	2039	**33.45**	759	33.99	207	18.84
2009/2010	43,041	60.41	31,602	64.22	8172	57.16	1892	41.86	3242	23.84	2019	31.05	818	34.84	228	14.91
2010/2011	43,412	**59.30**	31,711	**64.97**	8366	58.82	1685	38.22	3181	22.98	1982	28.46	914	35.67	220	13.64
2011/2012	42,129	59.62	31,516	63.83	9695	**61.63**	1726	**43.86**	3357	**21.81**	1968	26.93	1084	**40.96**	173	**20.81**
TOTAL	**410,085**	**M = 60.53 SD = 0.81**	**313,332**	**M = 64.33 SD= 0.58**	**69,170**	**M = 57.37 SD= 2.37**	**15,666**	**M = 38.78 SD = 4.22**	**32,247**	**M = 26.55 SD = 3.20**	**17,798**	**M = 29.54 SD = 3.11**	**5933**	**M = 34.45 SD = 4.3**	**2152**	**M = 14.96 SD = 3.15**

Bold items represent the minimum and the maximum values in each column

Table 2 Gender Representation in Greek Tertiary Education: Biology/Environment and Physics; 2002–2012

Gender Representation in Greek Tertiary Education, 2002–2012: Biology/Environment and Physics																
End of Academic Year	Biology/Environment								Physics							
	Freshmen		Graduates		Master		PhD		Freshmen		Graduates		Master		PhD	
	N	F %	NoD	F %	NoD	F %	NoD	F %	N	F %	NoD	F %	NoD	F %	NoD	F %
2002/2003	804	67.16	257	64.98	49	40.82	12	58.33	2044	43.44	1515	42.24	367	43.87	101	26.73
2003/2004	767	63.49	322	61.49	73	69.86	74	45.95	1930	43.83	1165	47.21	377	51.46	128	25.00
2004/2005	760	68.16	447	64.21	90	63.33	27	48.15	1945	42.11	1115	45.92	446	44.17	88	42.05
2005/2006	779	69.06	460	69.78	171	53.22	45	51.11	1958	44.99	1037	46.87	404	51.49	120	43.33
2006/2007	768	68.1	369	73.71	126	65.08	45	57.78	1980	47.98	1071	46.13	422	49.29	161	39.75
2007/2008	673	63.3	612	71.41	82	57.32	33	45.45	1870	47.54	1233	48.82	377	51.72	139	35.25
2008/2009	754	66.71	540	73.33	151	74.17	72	55.56	1893	51.24	1110	50	450	45.78	142	44.37
2009/2010	775	64.77	557	68.58	85	71.76	54	70.37	1929	50.03	1341	51.38	400	48.75	173	38.73
2010/2011	734	63.08	575	72	205	64.88	59	54.24	1885	48.01	1314	51.98	429	49.42	135	35.56
2011/2012	717	68.76	535	66.92	131	74.05	52	36.54	1895	50.5	1231	49.31	529	55.58	117	37.61
TOTAL	**7531**	**M = 66.30 SD = 2.26**	**4674**	**M = 69.15 SD = 3.94**	**1163**	**M = 64.57 SD = 9.98**	**473**	**M = 52.22 SD = 8.73**	**19,329**	**M = 46.92 SD = 3.04**	**12,132**	**M = 47.96 SD = 2.77**	**4201**	**M = 49.27 SD = 3.51**	**1304**	**M = 37.04 SD = 6.20**

Bold items represent the minimum and the maximum values in each column

Table 3 Gender representation in Greek Tertiary Education: Mathematics and Engineering; 2002–2012

Gender Representation in Greek Tertiary Education, 2002–2012: Mathematics and Engineering																
End of Academic Year	Mathematics								Engineering							
	Freshmen		Graduates		Master		PhD		Freshmen		Graduates		Master		PhD	
	N	F %	NoD	F %	NoD	F %	NoD	F %	**N**	F %	NoD	F %	NoD	F %	NoD	F %
2002/2003	2367	44.76	1286	**45.41**	165	35.76	44	**38.64**	1809	30.79	1085	**26.54**	209	**25.36**	80	27.50
2003/2004	2252	**42.56**	1067	49.95	147	35.37	20	30.00	1724	**28.89**	700	27.39	282	34.04	98	29.59
2004/2005	2138	46.61	1380	49.20	249	**34.54**	37	27.03	1697	31.88	1160	31.81	269	40.15	64	**25.00**
2005/2006	2154	47.91	1209	45.91	267	41.95	49	**20.41**	1539	31.32	721	28.83	290	33.79	56	33.93
2006/2007	2028	48.54	1222	49.35	414	43.24	61	24.59	1568	32.65	842	33.73	264	35.23	86	**44.19**
2007/2008	2068	49.49	1408	48.08	485	44.33	41	26.83	1550	33.03	1081	**35.62**	268	39.18	87	29.89
2008/2009	2231	49.95	1264	50.40	592	41.72	74	25.68	1747	**35.49**	1187	30.16	240	35.83	114	35.96
2009/2010	2262	49.56	1392	50.07	407	43.98	51	21.57	1832	33.84	1305	33.87	186	48.92	162	34.57
2010/2011	2273	49.55	1424	49.79	544	**45.96**	50	22.00	1793	32.35	1208	32.78	199	**49.75**	128	28.91
2011/2012	2224	**49.98**	1451	**51.21**	488	41.80	51	23.53	1858	31.16	1201	30.56	281	47.69	105	29.52
TOTAL	**21,997**	**M = 47.86 SD = 2.39**	**13,103**	**M = 48.97 SD = 1.81**	**3758**	**M = 42.12 SD = 3.90**	**478**	**M = 25.52 SD = 5.03**	**17,117**	**M = 32.14 SD = 1.71**	**10,490**	**M = 31.35 SD = 2.81**	**2488**	**M = 38.71 SD = 7.44**	**980**	**M = 32.14 SD = 5.19**

Bold items represent the minimum and the maximum values in each column

Table 1; cells of the last row of columns, 2, 3, 4, 6, 8, 5, 7 and 9 correspondingly).

Computing: As can be seen from Table 1, in every single year of the aforementioned decade there are fewer females than males in all four categories: freshmen, graduates, graduates of master's programmes, and PhD graduates, with a percentage of less than 40.96 % (see Table 1; columns, 11, 13, 15 and 17). The percentage of female freshmen in Computing departments varies from 21.81 to 30.85 % (see Table 1; column, 11), steadily decreasing as the end of the decade approaches (see Table 1; column, 11). In fact, from 2002/03 to 2011/12, the percentage of female freshmen drops by 9 %. On the other hand, the percentage of female graduates increases slightly from 22.63 % at the end of 2003/04 to 33.45 % at the end of 2008/09 but then decreases to 26.93 % at the end of 2011/12 (see Table 1; column, 13). The percentage of female master degree graduates in Computing varies from 25.63 to 40.96 % (see Table 1; column, 15) while the percentage of female PhDs varies from 9.47 to 20.81 % (see Table 1; column, 17). During the said decade, of the 32,247 freshmen, 26.55 % (SD = 3.20) were female, while of the 17,798 undergraduate degrees, 5933 master degrees and 2152 PhDs awarded in Computing in Greece, 29.54 % (SD = 3.11), 34.45 % (SD = 4.3) and 14.96 % (SD = 3.15) were awarded to women respectively (see Table 1; cells of the last row of columns, 10, 11, 12, 14, 16, 13, 15 and 17 correspondingly). It is worth noting here that despite the fact that there is a tendency for the percentage of female freshmen in Computing to drop, the percentage of female graduates of undergraduate studies (29.54 %) is, on average, higher than the percentage of female freshmen (26.55 %), while the percentage of female graduates of master's degrees (34.45 %) is higher than the respective number of female graduates of undergraduate studies. This indicates that there is no pipeline shrinkage between the different levels of studies in Computing (undergraduate studies, master's degree studies).

Bio/Env: Here, it is clear that female freshmen and female graduates outnumber male freshmen and male graduates respectively every single academic year of the mentioned decade (see Table 2; columns, 3 and 5). The percentage of female freshmen varies from 63.08 to 69.06 %, while the percentage of female graduates varies from 60.73 to 73.71 %. There are more female than male graduates of master's degrees in every year of the decade, with the exception of 2002/2003 (see Table 2; column, 7), while four years of the aforementioned decade experienced a greater number of female than male PhD graduates (see Table 2; column, 9). During the whole decade, of the 7531 freshmen in Bio/Env, 66.30 % (SD = 2.26) were female, of the 4674 undergraduate degrees, 1163 master degrees and 473 PhDs awarded, 69.15 % (SD = 3.94), 64.57 % (SD = 9.98) and 52.22 % (SD = 8.73) respectively were awarded to females (see Table 2; last cells of columns, 2, 3, 4, 6, 8, 5, 7 and 9 correspondingly). This means that there is no pipeline shrinkage between freshmen and graduates of undergraduate studies.

Phys: As far as Phys is concerned, female freshmen and graduates seem to be less prevalent than their male counterparts from 2002/03 to 2007/08, the percentage varying from 42.11 to 47.98 % for freshmen and 42.24 to 48.82 % for graduates of undergraduate studies, which is relatively close to the percentages for male freshmen and

graduates (see Table 2; columns, 11 and 13). However, in the academic years 2008/09, 2009/10 and 2011/2012, there are more female freshmen than male freshmen, while in 2008/09, 2009/10 and 2010/2011 female graduates of undergraduate studies are greater in number than male graduates. Four years of the decade reveal more female than male graduates of master's degrees, while the remainder reveal a percentage relatively close to that of the male graduates (see Table 2; column, 15). There are clearly fewer female than male PhD graduates in every single year of the decade (see Table 2; column, 17). In Phys, for the whole decade, of the 19,329 freshmen, 46.92 % (SD = 3.04) were female, while of the 12,132 undergraduate degrees, 4201 master's degrees and 1304 PhDs awarded, 47.96 % (SD = 2.77), 49.27 % (SD = 3.51) and 37.04 % (SD = 6.2) were awarded to females. It seems that, as far as Phys is concerned, females are less prevalent than males overall throughout the decade at all levels of study (see Table 2; last cells of columns, 10, 11, 12, 14, 16, 13, 15 and 17). This means that there is no pipeline shrinkage between freshmen, graduates of undergraduate studies and graduates of master's degree programs in Phys.

Math: As one can see from Table 3, in Math, female freshmen are less prevalent than males in every single academic year of the mentioned decade, the percentage varying from 42.56% to 49.98% (see Table, 3; column, 3). The situation is different as far as Math graduates are concerned: the percentage of female graduates varies from 45.41% to 51.21% (see Table, 3; column, 5) while female graduates are more prevalent than their male counterparts during the last 4 years of the mentioned decade. The percentage of female graduates of master's degrees varies from 34.54% to 45.96% while the percentage of female graduates of PhDs varies from 25% to 44.19% (see Table, 3; columns, 7 and 9). During the whole decade, in Math, of the 21,997 freshmen, 47.86% (SD=2.39) were females, while of the 13,103 undergraduate degrees, 3,578 master degrees and 478 PhDs awarded, 48.97% (SD=1.81), 42.12% (SD=3.9) and 25.52% (SD=5.03) respectively were awarded to females (see Table, 3; last cells of columns, 2, 3, 4, 6, 8, 5, 7 and 9 correspondingly). This means that there is no pipeline shrinkage between freshmen and graduates of undergraduate studies.

Eng: As far as Eng is concerned, females are less prevalent than males at all levels of study (see Table, 3; columns, 11, 13, 15 and 17). The percentage of female freshmen varies from 28.89% to 35.49%, the percentage of female graduates varies from 26.54% to 35.62% while the percentage of female graduates of master's degrees varies from 25.36% to 49.75% and the percentage of PhDs awarded to females varies from 25% to 44.19% (see Table, 3; columns, 11, 13, 15 and 17 correspondingly). Of the 17,117 freshmen, 32.14% (SD=1.71) were female, while of the 10,490 degrees, 2,488 master's degrees and 980 PhDs awarded in Eng over the whole decade, 31.35% (SD=2.81), 38.71% (SD=7.44) and 32.14% (SD=5.19) respectively were awarded to females (see Table, 3; last cells of columns, 10, 11, 12, 14, 16, 13, 15 and 17 correspondingly). There would appear to be no pipeline shrinkage among graduates of undergraduate studies, graduates of master's degree studies and PhD graduates.

On the whole, it seems that there is no pipeline shrinkage between freshmen and graduates of undergraduate studies in Computing and STEM and there was also no dropout from level (undergraduate studies) to level (master's degree studies) in Greek Computing, Phys and Eng departments.

3.2 Comparison of female-student representation in Computing with the remaining fields of STEM education in Greece during the decade 2002/03-2011/12: Trends and total numbers

3.2.1 Trends

Figures 1a, b and 2a, b diagrammatically display - in terms of percentages - the trends in female representation in Computing, STEM and 'Overall', from 2002/03 through 2011/2012 for different levels of study; namely: freshmen (Figure, 1), graduates of undergraduate studies (Figure, 2), master's degrees graduates (Figure, 3), and PhD graduates (Figure, 4). All Figures were created by using the MS-EXCEL software.

Freshmen: Figure 1a illustrates that, during the decade, the percentage of female freshmen in Greece steadily remains close to 60% and the percentage of female freshmen in Bio / Env clearly remains over 60%, approaching 70% in certain years. It also seems that female freshmen in Phys and Math follow the same upward trend throughout the decade, approaching and sometimes slightly exceeding the male percentage, while the percentage of female freshmen in Eng shows a steady trend of close to and over 30%. Computing is the only scientific discipline where the percentage of female freshmen decreases steadily throughout the decade, resulting in a very low percentage of just over 20%.

Graduates: Figure 1b indicates that, 'Overall', the percentage of the degrees awarded to females remained steadily over 60 %, while the percentage of degrees awarded to females in Bio/Env was even higher, in some years exceeding 70 %. The percentage of the degrees awarded to women in Phys and Math follows an upward trend throughout the decade, while the percentage of degrees awarded to females in Eng was close to and over 30 %. However, despite the low representation of female freshmen in Computing, there is a steady increase in the percentage of the degrees awarded to females from 2005/06 to 2009/10, at which date it exceeds 30 %.

Master's degree studies: Figure 2a demonstrates that the percentage of master degrees awarded to females in Computing steadily increased throughout the decade and slightly exceeded 40 % in 2011/12. At the same time, the percentage of master's degrees awarded in the rest of the STEM disciplines fluctuated, but over the decade as a whole there was a general upward trend.

PhDs: Figure 2b illustrates that the percentage of PhDs awarded to females in Computing increased from about 9.47 % in 2002/03 to 20.81 % in 2011/12 with an upward trend throughout the decade, but remained mostly under 20 % throughout the decade. The percentage of PhDs awarded to females in the remaining STEM disciplines showed fluctuations throughout the decade.

However, even though the percentages of degrees (undergraduate, master's, PhD) awarded to females in Computing increased over the last decade, they did remain lower than those in the other STEM disciplines and overall. It is also important to note here that, as we move through the different levels of studies in Computing, from first year to graduates of undergraduate studies to graduates of master's degrees, the percentage of females increased. There is also a clear upward trend in female PhD graduates.

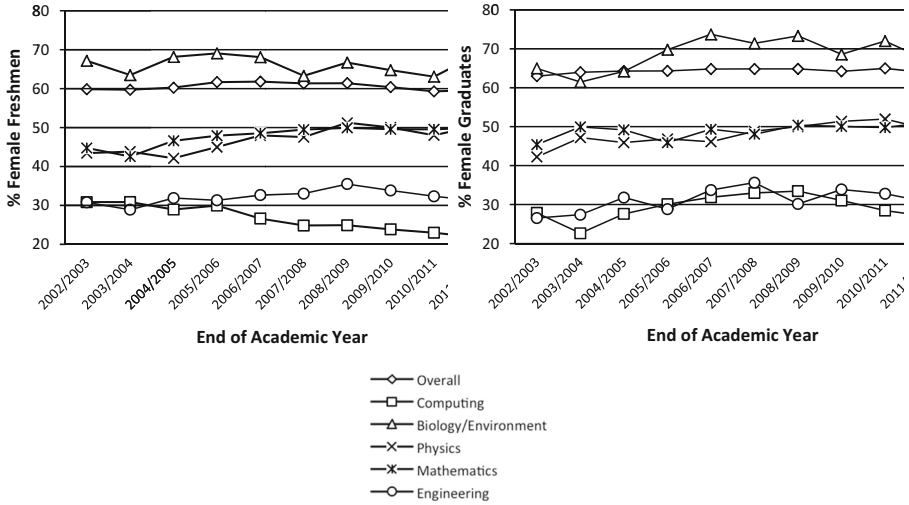

Fig. 1 **a** Percentage of female freshmen in Computing and STEM in Greece: 2002/03 to 2011/12. **b** Percentage of degrees awarded to females in Computing and STEM in Greece: 2002/03 to 2011/12

3.2.2 Total numbers

Table 4 depicts the gender (male and female) representation – in terms of total numbers - in Computing and STEM from 2002/03 through 2011/2012 for different levels of study: freshmen (columns, 2 and 3), graduates of undergraduate studies (columns, 4 and 5), master's degrees graduates (columns, 6 and 7), and PhD graduates (columns, 8 and 9).

As is shown in Table 4, during the said decade, female freshmen in Computing outnumber female freshmen in Bio/Env and Eng and remain relatively close in number in Phys and Math, but there are far fewer female than male freshmen in

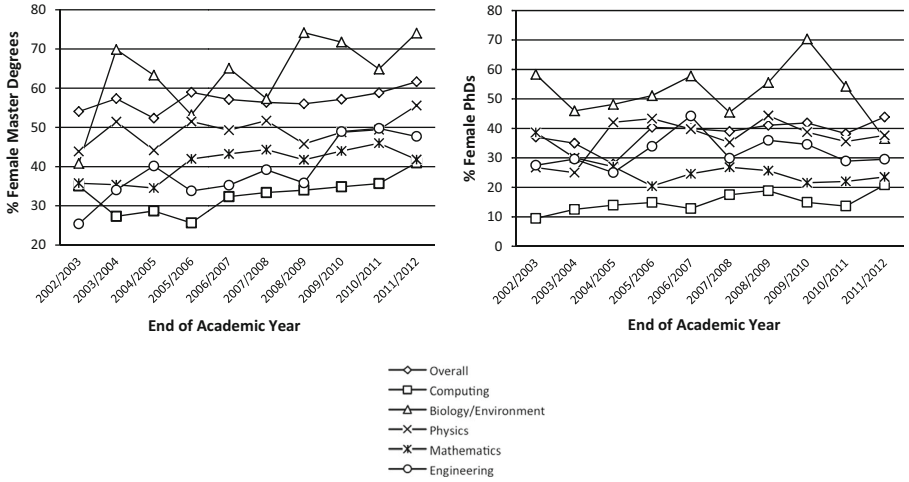

Fig. 2 **a** Percentage of master degrees awarded to females in Computing and STEM in Greece: 2002/03 to 2011/12. **b** Percentage of PhDs awarded to females in Computing and STEM in Greece: 2002/03 to 2011/12

Computing. Similarly, the number of undergraduate degrees earned by females in Computing exceeded or came close to that of those earned by females in the remaining STEM disciplines. The master's degrees and the PhD degrees earned by females in Computing were greater in number than degrees earned by females in the other STEM disciplines, with one exception: Phys. On the whole, it seems that the number of females in different levels of study in Computing (freshmen, graduates, master's degree graduates and PhD graduates) is greater than that of females in the same levels of study in STEM in Greece. This is because the number of Computing departments in Greece is far bigger than the number of departments included in each discipline of STEM (as shown in Section 2.1). Despite this fact, there are far fewer females in all the aforementioned levels of study in Computing than their male counterparts.

3.3 Gender representation of computing and STEM teachers in Greek secondary education: 2003/04 to 2012/13

Tables 5 and 6 demonstrate the total number (N) of male and female schoolteachers, as well as the percentage of those who were female (F%) teachers in all Greek Gymnasiums and Lyceums: (a) 'Overall', including the total number of teachers in each of the aforementioned levels, (b) in Computing, and (c) in STEM, including the following teaching disciplines: science (including Physics, Chemistry and Biology), math and engineering. The Mean (M) and the Standard Deviation (SD) of the percentage of females (F%) are also presented in the last row of these Tables.

3.3.1 Gender representation of computing and STEM teachers in Greek gymnasiums

Overall: As can be seen from Table 5 (column 3), female Gymnasium school teachers outnumber their male counterparts in every single year of the aforementioned decade. The percentage varies from 64.56 to 66.49 %. Despite the fact that the total number of schoolteachers continuously decreased (see Table; column 2), starting from 41,865 (in 2006/07) and ending in 35,636 (at 2012/13), the percentage of female schoolteachers overall remained stable. In fact, the average percentage of female schoolteachers in Greek Gymnasium during the above-mentioned decade was 65.66 % (SD = 0.55).

Table 4 Gender representation of students in Greek Tertiary education in Computing and STEM; 2002–12

	Freshmen		Graduates		Master		PhD	
	M	F	M	F	M	F	M	F
Computing	23,865	8562	12,540	5258	3889	2044	1830	322
Bio/Env	2538	4993	1442	3232	412	751	226	247
Phys	10,260	9069	6313	5829	2131	2070	821	483
Math	11,469	10,528	6686	6417	2175	1583	356	122
Eng	11,616	5501	7201	3189	1525	963	665	315

M = Male. F = Female

Computing As is shown in Table 5 (column 5), there are fewer female than male Computing schoolteachers in Gymnasium in every year of the decade. The percentage varies from 44.86to 46.77 %. The total number of Computing schoolteachers increased from 2003/04 to 2005/2006 and remained stable, with minor fluctuations, from thereon (see Table; column 4). The average percentage of female Computing schoolteachers in Gymnasium during the decade in question was 45.93 % (SD = 0.54).

Phys: Similarly, there were fewer female physics schoolteachers in Gymnasium than their male colleagues every single year of the aforementioned decade (see Table 5; column 7), their percentage varying from 41.63 to 44.81 %. The total number of physics teachers increased from 2003/04 through 2010/11, although over the next 2 years it decreased considerably (see Table 5; column 6). On average, female physics schoolteachers constituted 43.43 % of the total number of physics schoolteachers (SD = 0,9).

Math: Regarding female math schoolteachers, there were also fewer of them than their male counterparts in every single year of the aforementioned decade, their percentage varying from 34.77 to 41.56 % (see Table 5; column 9). The total number of math schoolteachers increased from 2003/04 to 2008/09, then decreased to 3987 in 2012/13, a number even lower than that of 2002/03 (see Table 5; column 8). On average, the percentage of female math schoolteachers that decade was 37.71 % of the total number of math schoolteachers (SD = 2.19). Numerically, on average, there were fewer female math schoolteachers (1652) than female phys schoolteachers (2052) but more than female Computing schoolteachers (918).

Table 5 Gender representation of secondary school teachers (Gymnasium) in Computing and STEM in Greece: 2003–2013

Start of Academic Year	Gender representation of secondary school teachers (Gymnasium) in Computing and STEM in Greece: 2003–2013							
	Overall		Computing		Phys		Math	
	N	F %	N	F %	N	F %	N	F %
2003/2004	36,853	**64.56**	1438	45.69	4348	**41.63**	4159	**34.77**
2004/2005	39,225	65.31	1585	**44.86**	4562	42.59	4294	35.54
2005/2006	40,788	64.99	1672	45.69	4637	42.96	4384	35.7
2006/2007	41,865	65.67	2111	46.14	4755	42.73	4430	35.89
2007/2008	41,174	65.95	2106	**46.77**	4832	43.65	4510	36.7
2008/2009	39,376	66.14	2173	45.56	4977	43.92	4646	38.27
2009/2010	39,250	65.57	2182	46.38	4979	43.60	4638	39.05
2010/2011	37,679	65.72	2253	45.85	5037	44.25	4480	39.49
2011/2012	37,160	66.09	2202	45.73	4744	**44.81**	4300	40.16
2012/2013	35,636	**66.49**	2153	46.63	4400	44.16	3987	**41.56**
Average	**38,901**	**M = 65.66 SD = 0.55**	**1988**	**M = 45.93 SD = 0.54**	**4727**	**M = 43.43 SD = 0.90**	**4383**	**M = 37.71 SD = 2.19**

Bold items represent the minimum and the maximum values in each column

Table 6 Gender representation of secondary school teachers (Lyceum) in Computing and STEM in Greece: 2003–2013

Gender representation of secondary school teachers (Lyceum) in Computing and STEM in Greece: 2003–2013

Start of Academic Year	General Lyceum - High School								Professional Lyceum									
	Overall		Computing		Phys		Math		Overall		Computing		Phys		Math		Eng	
	N	F %	N	F %	N	F %	N	F %	N	F %	N	F %	N	F %	N	F %	N	F %
2003/2004	22,170	49.24	998	**39.38**	3950	**21.74**	3762	18.05	15,898	**41.52**	2110	**37.49**	850	35.06	998	29.06	852	22.89
2004/2005	23,454	**49.2**	1162	38.81	4101	23.22	3924	17.8	16,594	42.34	2212	37.07	855	34.27	989	**27.91**	913	**22.45**
2005/2006	24,470	49.8	1207	37.03	4152	23.47	4133	**17.39**	15,865	42.21	2168	35.65	854	33.49	997	29.99	925	22.70
2006/2007	25,215	50.11	1529	37.15	4198	23.96	4207	17.48	15,614	42.49	2027	35.87	802	**32.54**	994	29.07	918	22.98
2007/2008	25,222	50.53	1508	**36.14**	4225	24.81	4253	19.12	14,682	42.20	1704	34.68	842	33.49	1042	30.23	805	23.98
2008/2009	26,548	51.94	1602	38.64	4346	26.65	4472	20.75	14,833	42.88	1476	35.09	928	35.67	1109	33.72	823	24.18
2009/2010	27,548	52.72	1618	38.01	4410	28.28	4633	20.63	18,766	**45.79**	1497	36.21	945	**39.37**	1172	33.87	863	24.10
2010/2011	26,568	52.96	1657	37.78	4173	28.79	4544	22.24	19,163	41.68	1399	34.67	957	36.68	1110	**43.42**	886	24.72
2011/2012	26,275	**53.55**	1575	38.92	4120	29.81	4646	22.96	18,174	41.98	1336	**33.68**	942	36.31	1183	37.36	865	24.51
2012/2013	25,158	53.45	1486	37.28	4006	**30.31**	4579	**24.91**	18,074	47.11	1306	34.38	860	37.33	1129	40.21	875	**24.80**
Average	**25,263**	**M = 51.35 SD = 1.67**	**1434**	**M = 37.91 SD = 0.97**	**4168**	**M = 26.10 SD = 2.90**	**4315**	**M = 20.13 SD = 2.47**	**16,766**	**M = 43.09 Std 1.78**	**1724**	**M = 35.66 SD = 1.15**	**884**	**M = 35.51 SD = 1.97**	**1072**	**M = 33.74 SD = 5.02**	**873**	**M = 23.71 SD = 0.84**

Bold items represent the minimum and the maximum values in each column

3.3.2 Gender representation of computing and STEM teachers in Greek lyceums

General lyceum

Overall: As one can see from Table 6, in GL, female schoolteachers were less prevalent than their male colleagues from 2003/04 to 2005/05, but more prevalent than male schoolteachers from 2006/07 on (see Table 6; column 3). Their percentage varies from 49.2 to 53.55 %. On average, the percentage of female schoolteachers in GL was 51.35 % (SD = 1.67). The total number of schoolteachers in GL increased steadily from 2003/04 to 2009/10, and decreased thereafter (see Table 6; column 2).

Computing: Female Computing schoolteachers in GL were less prevalent than their male counterparts every single year of the decade (see Table 6; column 5), the percentage varying from 36.14 to 39.38 %. On average, each year female Computing schoolteachers constituted 37.91 % of the Computing teaching staff at Lyceum (SD = 0.97). The number of Computing schoolteachers in GL increased from 2003/04 to 2010/11 and decreased thereafter (see Table; column 4).

Phys: Similarly, there were fewer female phys schoolteachers in GL than their male colleagues every single year of the mentioned decade (see Table 6; column 7). The percentage of female phys schoolteachers varies from 21.74 to 30.31 %, trending upward throughout the decade. On average, each year female phys schoolteachers constituted 26.1 % of the total Phys schoolteachers in GL (SD = 2.9). The total number of phys schoolteachers increased steadily from 2002/03 to 2009/10 (see Table 6; column 6).

Math: Female math schoolteachers in GL were less prevalent than their male counterparts every single year of the mentioned decade (see Table 6; column 9). The percentage of female math schoolteachers varies from 17.39 to 24.91 %, trending upward to the end of the decade. On average, the percentage of female math schoolteachers in GL was 20.13 % (SD = 2.47). The number of math schoolteachers increased from 2002/03 to 2009/10 remaining more or less constant thereafter (see Table 6; column 8).

Professional lyceum

Overall: In PL, there were, overall, fewer female schoolteachers than male schoolteachers in every year of the mentioned decade (see Table 6; column 11). The percentage varied from 41.52 to 45.79 %. On average, the percentage of female schoolteachers in PL was 43.09 % (SD = 1.78). The total number of schoolteachers in PL fluctuated during the decade in question, with an average of 16,766 schoolteachers per year (see Table 6; column 10).

Computing: Female Computing schoolteachers were less prevalent than male schoolteachers every year of the decade (see Table 6, column 13). The percentage varied from 33.68 to 37.49 %. On average, each year female Computing schoolteachers constituted 35.66 % (SD = 1.15) of the Computing teaching staff in PL. The number of non-female

Computing schoolteachers in PL increased during the first year of the aforementioned decade but decreased thereafter (see Table 6; column 12).

Phys: Similarly to Computing, there were fewer female phys schoolteachers in PL than male schoolteachers in every year of the decade (see Table 6, column 15). The percentage varied from 32.54 to 39.37 %. On average, the percentage of female phys schoolteachers in PL was 35.51 % (SD = 1.97).

Math: Female math schoolteachers in PL were also less prevalent than their male counterparts in every year of the decade (see Table 6, column 17). The percentage varied from 27.91 to 43.42 %. On average, the percentage of female math schoolteachers in PL was 33.74 % (SD = 5.02).

Eng: Eng schoolteachers teach only in PL. Each year of the decade saw fewer female eng schoolteachers than their male colleagues (see Table 6, column 19). The percentage varied from 22.42 to 24.80 %. On average, the percentage of female eng schoolteachers in PL was 23.71 % (SD = 0.84).

3.3.3 Cross sectional analysis

Overall: There were fewer schoolteachers in GL (on average 25,263) compared to their colleagues in Gymnasium (on average 38,901) but considerably more than those in PL (on average 16,766). The representation of female schoolteachers in Gymnasium (on average 65.66 %) is notably better than in GL (on average 51.36 %) and PL (on average 43.09 %). Specifically, there were 25,542 female schoolteachers in Gymnasium, 12,993 in GL and 7224 in PL.

Computing: On average, the number of Computing schoolteachers in Gymnasium was 1988, in PL 1724 and in GL 1434. There were, on average, 914 female Computing schoolteachers in Gymnasium every year, while in GL this number was 544 and in PL 615. However, on average, female Computing schoolteachers are better represented in Gymnasium (45.93 %), compared to GL and PL (37.91 % and 35.66 % respectively).

Phys: Phys schoolteachers in Gymnasium (on average 4727) slightly outnumbered their colleagues in GL (on average 4168) but were considerably greater in number than those in PL (on average 884). There were on average 2054 female phys schoolteachers in Gymnasium every year, while in GL they averaged 1088 and in PL 314. The representation of female phys teachers in Gymnasium is higher (on average 43.43 %) compared to PL (on average 35.51 %) and considerably higher compared to GL (on average 26.10 %).

Math: There were slightly more math schoolteachers in Gymnasium (on average 4383) than those in GL (on average 4351), and far more than their colleagues in PL (on average 1072). The number of female math schoolteachers in Gymnasium was 1652, while in GL they averaged 869 and in PL 362. The percentage of females differs (on average 37.71 % in Gymnasium, 33.74 % in PL and 20.13 % in GL) signifying that females are better represented in Gymnasium.

3.4 Comparison of female teacher representation in computing and in the remaining fields of STEM education in Greece during the decade 2003/04–2012/13

Gymnasium Overall, from an average of 38,901 schoolteachers in Gymnasium during the said decade, 25,542 (65.66 %) were female, 4727 were phys teachers (12.15 %), 4383 were math teachers (11.27 %) and just 1988 were Computing teachers (5.11 %). On the whole, despite the fact that Computing schoolteachers in Gymnasium constituted a small part of the teaching staff, female teachers were better represented here (45.93 %) than in other related disciplines such as physics (43.43 %) and math (37.71 %). However, numerically, on average, there were more female physics schoolteachers (2054) than female math schoolteachers (1652) and female Computing schoolteachers (914).

General lyceum In General Lyceum, on average, every year of the mentioned decade, there were 25,263 teachers, of which 12,972 (51.35 %) were female. 4315 of them were math schoolteachers (17.09 %), 4168 phys schoolteachers (16.50 %) and only 1434 Computing schoolteachers (5.68 %). However, despite the fact that Computing schoolteachers in Lyceum also constituted a small proportion of the teaching staff, female teachers were better represented in the Computing teaching staff (37.91 %) compared to the representation of female teachers of other related disciplines, such as physics (26.10 %) and math (20.13 %). Nevertheless, on average, female phys schoolteachers (1088) were more prevalent than female math schoolteachers, (869) and greater in number than female Computing schoolteachers (544).

Professional lyceum In PL, on average, in every year of the aforementioned decade, there were 16,766 schoolteachers of all disciplines. 1724 of them were Computing schoolteachers (10.28 %), 1072 math schoolteachers (6.39 %), 884 phys schoolteachers (5.27 %), and 873 Eng schoolteachers (5.21 %). There were more Computing schoolteachers in PL than schoolteachers in related disciplines, and female Computing teachers were better represented in the Computing teaching staff (35.66 %) compared to the representation of female teachers of other related disciplines, e.g. physics (35.51 %), math (33.74 %) and eng (23.71 %). It is worth noting here that, on average, every year there were more female Computing schoolteachers (615) than female math schoolteachers (362), female phys schoolteachers (314), and female eng schoolteachers (207).

4 Discussion and conclusions

The results arising from the analysis of the data presented in this paper can be viewed as both alarming and encouraging in terms of the participation of female freshmen, graduates, master's degree graduates and PhD graduates in Greek Computing Tertiary Computing and STEM Education. In fact, in every single year of the decade: (a) Females were less prevalent than males at all levels of study- namely: freshmen, graduates, master's degree graduates and PhD graduates - in Computing and Eng, (b) Females were less prevalent than males at PhD level in Computing and STEM as well as 'Overall', (c) There were more females than males at all levels of study – except PhD

- in Bio/Env and 'Overall', (d) there was no excess of males over females in Phys (freshmen, graduates and master's degree graduates) or in Math graduates.

It can be viewed as a cause for concern that female freshmen in Computing departments were less prevalent than male freshmen every single year of the decade under study, their representation a potentially alarming downward trend as we move towards the end of the decade. This contrasts with the fact that there are more female than male freshmen in Greece. It is also alarming that the percentages of female freshmen in Computing departments are lower than in any other STEM discipline. In fact, female freshmen were: (a) steadily more prevalent than male freshmen in Bio/Life departments, (b) close in number to that of male freshmen in Phys departments, in some years actually outnumbering them, (c) fewer than their male counterparts in Math departments but still close in number over most of the years of the decade, (d) fewer than their male counterparts but following an upward trend for five years of the decade in Eng departments. These results support previous research findings (Gürer and Camp 2002; Camp 2012) that indicate there are fewer women than men in STEM departments – with the exception of Bio - and especially in Computing.

Despite the fact that the percentages of female graduates of Computing department undergraduate programs were still, for most of the decade, the lowest of all STEM disciplines, the upward trend is an encouraging mark. At the same time, the number of female graduates of undergraduate programs – in total - was regularly greater than that of male graduates in Greece, and the same stands for female graduates of Bio/Life departments. There is no clear predominance of male over female graduates in either Phys or Math departments, nor is there a clear trend for the percentages of female graduates from Eng departments. However, these percentages are equally as alarming as those for female graduates from Computing departments.

The upward trend in the percentages of female graduates of master's degree programs in Computing departments over the last 7 years of the decade under study is another promising point. It verifies that a considerable percentage of women pursue and achieve a Computing master's degree after graduation. Nevertheless, the percentages of female graduates from master's degree programs from Computing departments were the lowest, almost every year of the decade, in all STEM disciplines. Female graduates of master's degree programs during the said decade were: (a) greater in number than male graduates in the total population of master's degree graduates in Greece as well as in Bio/Life departments, (b) close to or greater than the number of male graduates in phys departments, (c) fewer than male graduates in Math and Eng departments.

Despite the low percentages, as the decade progressed there was an observable increase in female graduates of PhDs in Computing departments. Nevertheless, the percentages of female graduates of PhDs in Computing departments were the lowest of all STEM disciplines. In fact, there were also fewer PhDs awarded to females in Phys, Math and Eng departments than those awarded to males, while only PhDs awarded to females in Bio/Life departments were greater in number than those awarded to males.

On the whole, the results of this study suggest that, even in the era of the Internet and Social media, where more women than men are online and use these media every day, women are still under-represented in Computing at Tertiary level (freshmen, graduates, master's degree graduates and PhD graduates) in Greece over the last decade. However,

unlike previous research findings, the "pipeline shrinkage problem" (Gürer & Camp, 2002) would appear to have no effect on Greek undergraduate studies in terms of Computing and STEM education. In addition, it seems, there was no dropout from level (undergraduate studies) to level (master's degree studies) in Greek Computing, Phys and Eng departments during the said decade. It is remarkable that the percentage of female master's degree graduates in each of the aforementioned disciplines is higher than the percentage of female graduates of undergraduate studies, which in turn is higher than the percentage of female freshmen. It seems that recruitment rather than retention is the main problem in Computing and STEM education. This means that there is a clear need to attract and convince women to enter the Computing and STEM education fields. As far as Computing education is concerned, once women enter the field, it seems that they do remain, continuing their studies and pursuing degrees at graduate levels. In addition, there are studies suggesting that, once women enter a Computing department, they perform as well as men (Ilias and Kordaki 2006), they find successful pathways by selecting Computing sections they prefer (Kordaki and Berdousis 2013) and they are good at them (Berdousis and Kordaki 2015).

As far as secondary level education teachers are concerned, for every single year of the decade: (a) Female teachers were less prevalent than their male counterparts in Computing and STEM at all levels of secondary education; namely, these are: Gymnasium, GL and PL. (b) Female teachers 'Overall' were greater in number than their male counterparts in Gymnasium and in GL.

As for Computing schoolteachers, the results from this study highlight an issue that can be connected to the low participation of female freshmen in Computing departments. Despite the fact that female schoolteachers are more prevalent than male schoolteachers in secondary education, there are fewer female schoolteachers in Computing. In fact, there are even fewer in Lyceum (General and Professional), one step before students make decisions about their university studies and career, where the mentor/role model has a significant impact, more so than at any other level of education. The low representation of female schoolteachers would also seem to be an issue for the rest of the STEM disciplines. There were constantly fewer female schoolteachers in phys, math and eng than their male counterparts. However, female Computing teachers, on average, were better represented in Computing teaching staff compared to the representation of female teachers in other related disciplines, i.e. physics, math and eng, in Gymnasium, GL and PL. Nevertheless, there were more female physics schoolteachers than female math schoolteachers, and considerably more than female Computing schoolteachers. Here it is worth mentioning that, the lack of female mentors/role models in high school Computing and STEM education is a non-encouraging factor, due to the fact that, they could influence female students to select these disciplines for their University studies and future careers (Lunenberg et al 2007).

4.1 Implications of this study for computing teachers and researchers

Computing teachers can utilize the results of this study so as, firstly, to realize and be aware of the issue addressed - that is, the lack of female students in Computing departments - and, secondly, to try finding answers to the under-representation of women in Computing phenomenon and possibly perceive the importance of their role

and the impact they can have on their students' choice of Computing as a field of education, especially in the case of women. To this end, the results of this study may be the starting point for Greek Computing teachers to rethink their beliefs and practices concerning classroom teaching approaches so that they might cater for both boys and girls. In addition, taking into account that the real issue addressed in this study is the need for recruitment and not so much retention of women in Computing departments, researchers from Computing education - in collaboration with Computing teachers - could form appropriate teacher education programs with a positive effect on the recruitment of women in Computing.

4.2 Limitations of the study and future research directions

This study focuses on the investigation of gender representation of students and secondary level education teachers in Computing and STEM education during the decade 2002–2012 in Greece. Although some of the results of this study are in line with the findings of other studies, this study concerns a certain period of time as well as a particular population and a country with a specific secondary and tertiary education system. Any generalization of these results should be undertaken with caution and be limited to countries and populations that have similar characteristics to those of the participants in this study. Any research finding that differs from those of other studies should be handled with the same prudence.

This study yields interesting research prospects. The results highlight the deficient recruitment of women in the field of Computing, expressed primarily by the poor participation of women in Computing departments, especially as far as freshmen are concerned. The lack of female Computing mentors and role models in secondary education, only one step before students select their University studies, and consequently their career choice, is an issue over which there appears a need for serious concern. Consequently, the next item in the authors' research agenda is the investigation of the beliefs that Computing teachers hold about: (a) their role as mentors of their students of both genders, and (b) a gendered view of their students' roles, potentials and prospects regarding Computing. Investigation of Computing teachers' real practices from a gender perspective is also essential. Teachers' beliefs and practices can then be taken into account in the design of appropriate Computing teacher education programs where teachers' beliefs and practices are investigated in relation to one another, aiming at their transformation. The aim of these programs could be the elimination of teachers' traditional stereotypes regarding a male-oriented Computing field and the adoption of a balanced approach that also acknowledges women's strengths and essential characteristics.

It is hoped that this paper has provided useful insights into the representation of both genders in Computing, as far as students in undergraduate and graduate studies and Computing schoolteachers in secondary education are concerned. Computing schoolteachers in particular can exploit the results in order to be aware of the underrepresentation of women in Computing who realize that their role can be crucial. It is also hoped that the results emanating from two different but strongly connected levels of education can trigger further research about Computing schoolteachers' roles, beliefs and practices that may positively affect the selection of Computing as a field of study and career by students of both gender.

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