Gender Issues in Computer Science Education in Greece: Representation, Performance, Preferences, Teachers' Beliefs and Practices

by

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Υπεύθυνη δήλωση

Η συγκεκριμένη Διδακτορική Διατριβή είναι πρωτότυπη και εκπονήθηκε αποκλειστικά για την απόκτηση του Διδακτορικού Διπλώματος του Τμήματος Πολιτισμικής Τεχνολογίας και Επικοινωνίας. Κάθε βοήθεια, την οποία είχα για την προετοιμασίας της, αναγνωρίζεται πλήρως και αναφέρεται επακριβώς στην εργασία. Επίσης, επακριβώς αναφέρω στην εργασία τις πηγές, τις οποίες χρησιμοποίησα, και μνημονεύω επώνυμα τα δεδομένα ή τις ιδέες που αποτελούν προϊόν πνευματικής ιδιοκτησίας άλλων, ακόμη και εάν η συμπερίληψή τους στην παρούσα εργασία υπήρξε έμμεση ή παραφρασμένη. Γενικότερα, βεβαιώνω ότι κατά την εκπόνηση της διδακτορικής διατριβής έχω τηρήσει απαρέγκλιτα όσα ο νόμος ορίζει περί προστασίας διανοητικής ιδιοκτησίας και έχω συμμορφωθεί πλήρως με τα προβλεπόμενα στο νόμο περί προστασίας προσωπικών δεδομένων και τις αρχές της Ακαδημαϊκής Δεοντολογίας.

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To my lady and our little princess

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Abstract

Over the last decades, gender issues in Computer Science (CS) as well as in Science, Technology, Engineering and Math (STEM) disciplines have captured the attention of many researchers. Research in several countries has revealed that females are underrepresented in CS from the early students' years to work years. Yet, in Greece, the gender representation in CS education has not been examined on a systematic basis. Additionally, research has revealed that, among other factors, stereotypes and school education affect females' engagement in CS. Although there is not consistent evidence in CS, it seems that socially constructed 'myths' and negative stereotypes about females' cognitive skills and academic ability in CS deter them from entering the field. Regarding school education, current empirical research in Computing Teachers' (CTs) gender-related beliefs and practices is scarce despite the existence of strong evidence, mainly from STEM fields, that teachers' gendered beliefs and practices may (negatively) affect females' engagement, motivation and career decisions.

Therefore, the aim of this thesis is mainly threefold: (a) to investigate systematically the gender representation in CS education in Greece, (b) to study gender differences in preferences and performance in CS courses, and (c) to examine CTs' gender-related beliefs and practices uncovering any possible associations. To this end, three individual studies were designed.

Thus, a longitudinal embedded-single case study (*Study1)* focused on the investigation of gender representation in Greek secondary CS and STEM education in terms of teachers, as well as in Greek tertiary CS and STEM education in terms of students/graduates and faculty members, during the decade 2003-12. Drawn on quantitative data from the Hellenic Statistical Authority, this study revealed that: (a) female teachers/students/graduates/faculty members were less prevalent than their males counterparts in CS secondary and tertiary education; (b) female teachers were better represented in CS compared to the rest STEM disciplines in secondary education; (c) the percentages of female students/graduates/faculty members in CS Tertiary education were the lowest among STEM disciplines; (d) there was no pipeline shrinkage between female freshmen and graduates of undergraduate studies in CS and there was also no female dropout from undergraduate studies to master's degree studies in Greek CS departments; (e) female faculty members in CS were better represented in the position of lecturer, while higher ranks were dominated by males.

In addition, a single case study (*Study2)* examined gender differences in terms of student preferences and performance in undergraduate courses included in the entire curriculum of a CS department. Exploiting data from a CS department in Greece, the quantitative analysis of 89 graduate degrees revealed that: (a) there are not striking difference in males' and females' performance, except a few courses in which males perform better than females at math and programming, while females perform better in courses related to interfaces between people and computers, and (b) at a statistically significant level, males preferred courses related to hardware/software engineering, while females preferred courses regarding theoretical CS, humanities and social sciences.

Finally, a single case study (*Study3)* investigated CTs' gender-related beliefs, examined their classroom practices and explored any associations between their expressed beliefs and their actual practices in class. Twenty CTs participated and their beliefs were elicited through structured interviews, while their practices were investigated through non-participant observations, using structured observation sheets. The qualitative analysis of the CTs' interviews revealed that CTs expressed several empowering/constraining, gender-neutral/gendered and gender-sensitive/gender-insensitive beliefs, and in reality, a mix of (inconsistent) beliefs do seem to coexist in the minds of most of them. In terms of CT gender, males expressed mostly constraining, gendered beliefs in favor of boys, as well as several gender-insensitive beliefs, whereas females expressed mostly empowering, gender-neutral and gender-sensitive beliefs. The quantitative analysis of the class observations showed that CTs' practices fall into five different teaching profiles; a gender neutral one, another two favoring boys on the whole, and the last two in favor of girls on the whole. The investigation of the relationships between CTs' expressed beliefs and their practices indicated that some of their beliefs are suppressed by others more central beliefs, mostly gendered beliefs, which are reflected in their practices. The analysis also showed that, based on their beliefs and practices, there are those CTs who tend to: (a) maintain the gender gap; (b) broaden the gender gap; (c) bridge the gender gap.

It is hoped therefore that this work will serve as a valuable reference for CTs, CTs educators, CS students, CS faculty and researchers in order to raise their awareness of the gender gap issue in CS so as to make those critical changes to reverse the situation and eventually bring to an end this vicious cycle.

Περίληψη

Τα τελευταία χρόνια πολλές μελέτες διεθνώς εστιάζουν στις διαφορές φύλου και στη σχέση τους με την Επιστήμη των Υπολογιστών (ΕΥ) καθώς και σχετικούς με την Επιστήμη, την Τεχνολογία, τη Μηχανική, και τα Μαθηματικά [Science, Technology, Engineering and Mathematics (STEM)] τομείς. Σε πολλές χώρες φαίνεται ότι οι γυναίκες συμμετέχουν συστηματικά λιγότερο σε όλους τους τομείς που σχετίζονται με την ΕΥ, τόσο στην εκπαίδευση όσο και στον επαγγελματικό χώρο. Ωστόσο, στην Ελλάδα, δεν υπάρχουν συστηματικές μελέτες που να αναδεικνύουν την έκταση του ζητήματος της υπο-αντιπροσώπευσης των γυναικών στην ΕΥ. Τα αίτια της μειωμένης συμμετοχής των γυναικών στην ΕΥ έχουν μελετηθεί διεξοδικά και έρευνες έχουν αναδείξει, ανάμεσα σε άλλους σημαντικούς παράγοντες, πως τα στερεότυπα και η σχολική εκπαίδευση επηρεάζουν τις αντιλήψεις, τις στάσεις και το ενδιαφέρον των γυναικών, αποτρέποντας τες πολλές φορές από το να επιλέξουν την ΕΥ ως αντικείμενο σπουδών ή καριέρας. Τα αρνητικά στερεότυπα για τις γνωστικές ικανότητες και τις ακαδημαϊκές επιδόσεις των γυναικών στο χώρο της ΕΥ και των STEM συχνά επηρεάζουν αρνητικά τη συμμετοχή των γυναικών. Ωστόσο, υπάρχουν αποδείξεις, ειδικά στο χώρο των STEM, ότι δεν υφίστανται πραγματικά τέτοιες διαφορές ανάμεσα στα δύο φύλα και πως αυτές είναι απλά κοινωνικά κατασκευασμένες. Επιπλέον, έρευνες από το χώρο των STEM έχουν δείξει πως άντρες και γυναίκες κάνουν διαφορετικές επιλογές μαθημάτων ακόμα και μέσα στο ίδιο πεδίο, υπογραμμίζοντας ότι υπάρχουν διαφορές στις προτιμήσεις των δύο φύλων. Όσον αφορά τη σχολική εκπαίδευση, αν και δεν υπάρχουν εμπειρικές μελέτες σχετικά με τις αντιλήψεις και τις πρακτικές των εκπαιδευτικών Πληροφορικής (εκ.Π) σε σχέση με το φύλο, αποδεικνύεται, κυρίως στα πεδία των STEM, πως οι αντιλήψεις και οι πρακτικές των εκπαιδευτικών μπορεί να επηρεάσουν (αρνητικά) το ενδιαφέρον, τη στάση και τις επιλογές των γυναικών.

Σε αυτό το πλαίσιο, ο σκοπός της συγκεκριμένης διατριβής είναι τριπλός: (α) να εξετάσει συστηματικά το θέμα της υπο-αντιπροσώπευσης των γυναικών στην εκπαίδευση της ΕΥ στην Ελλάδα, (β) να διερευνήσει πιθανές διαφορές των δύο φύλων στις προτιμήσεις και τις επιδόσεις στην ΕΥ, και (γ) να εκμαιεύσει τις αντιλήψεις των εκ.Π σε σχέση με το φύλο και να αναδείξει τις πρακτικές τους στη σχολική τάξη, αποκαλύπτοντας πιθανές συσχετίσεις ή/και ασυνέπειες. Για κάθε έναν από τους επιμέρους στόχος της διατριβής σχεδιάστηκε μια μελέτη περίπτωσης.

Μια διαχρονική (longitudinal) μελέτη περίπτωσης (*Μελέτη1*) εστίασε στην διερεύνηση της αντιπροσώπευσης των δύο φύλων στη ΕΥ και στα πεδία των STEM στη δευτεροβάθμια εκπαίδευση στην Ελλάδα, όσον αφορά στους εκπαιδευτικούς, αλλά και στην τριτοβάθμια

Ελληνική εκπαίδευση όσον αφορά φοιτητές/απόφοιτους και μέλη ΔΕΠ για τη δεκαετία 2003-12. Με βάση ποσοτικά δεδομένα από την Ελληνική Στατιστική Αρχή, η μελέτη ανάδειξε ότι: (α) οι γυναίκες καθηγήτριες/φοιτήτριες/απόφοιτοι/μέλη ΔΕΠ ήταν λιγότερες από τους άντρες στην δευτεροβάθμια και τριτοβάθμια εκπαίδευση της ΕΥ στην Ελλάδα, (β) οι γυναίκες εκπαιδευτικοί στη δευτεροβάθμια εκπαίδευση αντιπροσωπεύονται καλύτερα στην ΕΥ σε σχέση με τα υπόλοιπα πεδία των STEM, (γ) τα ποσοστά των γυναικών φοιτητριών/αποφοίτων/μελών ΔΕΠ στην τριτοβάθμια εκπαίδευση ήταν τα χαμηλότερα σε σχέση με τα υπόλοιπα πεδία των STEM, (δ) τα ποσοστά των φοιτητριών που εισέρχονται σε τμήματα ΕΥ είναι ανάλογα με αυτά που αποφοιτούν από τις προπτυχιακές σπουδές και φαίνεται ότι ένα σημαντικό ποσοστό συνεχίζει και σε μεταπτυχιακές σπουδές, (ε) οι γυναίκες μέλη ΔΕΠ στην ΕΥ αντιπροσωπεύονται καλύτερα στη βαθμίδα του λέκτορα, ενώ οι υψηλότερες βαθμίδες κυριαρχούνται από άντρες.

Επιπλέον, μια ποσοτική μελέτη περίπτωσης (*Μελέτη2*) εξέτασε τις διαφορές φύλου όσον αφορά στις προτιμήσεις και στις επιδόσεις φοιτητών σε όλα τα προπτυχιακά μαθήματα ενός τμήματος ΕΥ. Αξιοποιώντας δεδομένα από ένα τμήμα ΕΥ στην Ελλάδα, η ποσοτική ανάλυση 89 πτυχίων αποφοίτων του τμήματος έδειξε ότι: (α) δεν υπάρχουν σημαντικές διαφορές στις επιδόσεις ανδρών και γυναικών, εκτός από λίγα μαθήματα στα οποία οι άντρες είχαν καλύτερη επίδοση στα μαθηματικά και τον προγραμματισμό, ενώ οι γυναίκες είχαν καλύτερες επιδόσεις σε μαθήματα που σχετίζονται με την αλληλεπίδραση ανθρώπου-υπολογιστή, και (β) σε στατιστικά σημαντικό επίπεδο, οι άντρες προτίμησαν μαθήματα σχετικά με τα συστήματα λογισμικού, ενώ οι γυναίκες μαθήματα που σχετίζονταν με θεωρητικά θέματα στην ΕΥ, τις ανθρωπιστικές και τις κοινωνικές επιστήμες.

Τέλος, μια μελέτη περίπτωσης (*Μελέτη3*) διερεύνησε τις αντιλήψεις και τις πρακτικές εκ.Π σχετικά με το φύλο των μαθητών τους αναζητώντας πιθανές συσχετίσεις. Μέσα από ημι-δομημένες συνεντεύξεις μελετήθηκαν οι αντιλήψεις είκοσι εκ.Π που συμμετείχαν στην έρευνα, ενώ οι πρακτικές τους διερευνήθηκαν μέσω μη συμμετοχικής παρατήρησης, χρησιμοποιώντας δομημένα φύλλα παρατήρησης. Η ποιοτική ανάλυση των συνεντεύξεων έδειξε ότι οι εκ.Π εξέφρασαν πολλές *διευκολυντικές/περιοριστικές* αντιλήψεις σχετικά με τους ίδιους ως εκπαιδευτικούς, τη φύση του μαθήματος της ΕΥ και τη διδασκαλία και τη μάθησή του, *ουδέτερες/διαφοροποιημένες* ως προς το φύλο αντιλήψεις, καθώς και *ευαισθητοποιημένες/μη ευαισθητοποιημένες* ως προς τις διαφορές φύλου στην ΕΥ αντιλήψεις. Στην πραγματικότητα, ένα μίγμα (ασυνεπών) αντιλήψεων φαίνεται να συνυπάρχει στο μυαλό των περισσότερων από τους εκ.Π. Όσον αφορά το φύλο των εκ.Π, οι άνδρες εξέφραζαν κυρίως περιοριστικές αντιλήψεις σχετικά με τους ίδιους ως εκπαιδευτικούς και τη διδασκαλία/μάθηση της ΕΥ, αντιλήψεις ευνοώντας τα αγόρια, καθώς και αρκετές μη ευαισθητοποιημένες αντιλήψεις ως προς τις διαφορές φύλου στην ΕΥ. Από την άλλη μεριά, οι γυναίκες εξέφραζαν κυρίως διευκολυντικές, ουδέτερες αλλά και ευαισθητοποιημένες ως προς το φύλο αντιλήψεις. Η ποσοτική ανάλυση των παρατηρήσεων έδειξε ότι οι πρακτικές των εκ.Π εμπίπτουν σε πέντε διαφορετικά προφίλ διδασκαλίας: ένα ουδέτερο σε σχέση με το φύλο των μαθητών, δύο προφίλ που συνολικά ευνοούν τα αγόρια και τα δύο ακόμα προφίλ που συνολικά ευνοούν τα κορίτσια. Η διερεύνηση των σχέσεων μεταξύ των εκφρασμένων αντιλήψεων των εκ.Π και των πρακτικών τους έδειξε ότι ορισμένες από τις αντιλήψεις τους παραμερίζονται από άλλες πιο κεντρικές αντιλήψεις, κυρίως από αντιλήψεις υπέρ του ενός φύλου έναντι του άλλου, οι οποίες αντικατοπτρίζονται στις πρακτικές τους. Η ανάλυση των δεδομένων επίσης, έδειξε ότι, οι εκ.Π που συμμετείχαν στην έρευνα εντάσσονται σε τρεις κατηγορίες οι οποίες αφορούν στο κατά πόσον με βάση τις αντιλήψεις και τις πρακτικές τους τείνουν: (α) να διατηρούν, (β) να διευρύνουν, ή (γ) να γεφυρώνουν το χάσμα μεταξύ των φύλων στην ΕΥ.

Η συγκεκριμένη διατριβή μπορεί να αποτελέσει σημείο αναφοράς για τους εκ.Π, τους επιμορφωτές τους, τους φοιτητές και τα μέλη ΔΕΠ στην ΕΥ καθώς και τους ερευνητές στο συγκεκριμένο επιστημονικό πεδίο προκειμένου, όχι μόνο για να ενημερωθούν για την υπο-αντιπροσώπευση των γυναικών στην ΕΥ στην εκπαίδευση στην Ελλάδα και τις διαφορετικές προτιμήσεις των δύο φύλων σε τομείς της ΕΥ, αλλά να συνειδητοποιήσουν τη σημασία του ρόλου τους στη διεύρυνση/γεφύρωση του χάσματος μεταξύ των δύο φύλων στην ΕΥ. Στη βάση των αποτελεσμάτων της συγκεκριμένης διατριβής μπορούν να σχεδιάσουν και να δοκιμάσουν στην πράξη κατάλληλες παρεμβάσεις για τη γεφύρωση αυτού του χάσματος.

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List of Abbreviations – Acronyms

Bio/Env	Biology/Environment
CEng	Computer Engineering
CS	Computer Science
CT	Computing Teacher
CTCS	Computer Technology and Computer Systems
C+STEM	Computing and Science, Technology, Engineering, Mathematics
Dept	Department
DL	Digital Literacy
Eng	Engineering
GE	General Education
GSE	Greek Secondary Educations
GTE	Greek Tertiary Education
ICT	Information and Communication Technologies
Math	Mathematics
M&P	Mathematics and Physics
SS	Software Systems
STEM	Science, Technology, Engineering, Mathematics
TCS	Theoretical CS

Chapter 1.

Introduction

Summary: In this chapter an introduction in gender issues in Computer Science leads both to the statement of the research problem and the purpose of the present thesis. The threefold aim of the thesis is defined and the research questions are introduced. Subsequently, a review of the research methodology and the thesis contribution are also presented. Finally, the chapter concludes with the outline of the thesis and the list of publications that were produced in the frame of this research.

1.1 Background of the Study

Women have been involved in Computer Science (CS) literally from the moment of the creation of this scientific discipline and have passionately programmed computers for many decades, shaping the evolution of information technology. In the early days of computers, women were well-represented in the field, entering the emerging CS profession in unusually big numbers (Ensmenger, 2010). It was in the late-1980s that women stop entering the field, and the proportion of women studying CS actually began falling dramatically (Camp, 2012).

Since then, the gender gap in CS has raised global concerns that have motivated excessive research during the last decades, investigating the extent of the under-representation of women in CS education and workforce by addressing possible key factors which affect women's participation in CS, suggesting and implementing strategies to recruit more women into the field.

Despite the efforts made, women have been continuously under-represented in CS in both higher education and the workforce. Computer Science remains a heavily male-dominated field, even after several years of extensive attempts to promote female participation. The ratio of women to men involved in CS 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 in a number of countries (Camp, 2012; C. C. Hayes, 2010a; Hill, Corbett, & St Rose, 2010; Misa, 2010a).

In fact, in spite of the early women's success in CS, the number of females in the field has been falling since the mid-1980s, whereas women continued to increase their representation in most of Science, Technology, Engineering, and Math (STEM) fields. The descending trend in women representation was unique in CS, as the proportion of undergraduate degrees awarded to women in all disciplines has actually increased the last decades. Likewise, the percentage of undergraduate degrees awarded to women in biological/life sciences, engineering, and physical sciences did increase (Camp, 2012).

A clearer picture of the representation of women in CS in the US reveals that there are *"distinctive trajectories and dynamics"* at the undergraduate level compared to the graduate level (C. C. Hayes, 2010b). While women's participation in the graduate level (master's and doctoral degrees) is still low, there has been a slight increase across the decades. It is at the undergraduate level, since the *"turning point"* in the mid-1980, in which the proportion of women earning CS degrees constantly declines. Compared to other STEM disciplines in which the proportion of women has been steadily increased, CS seems to be a field of extremes, being both the fastest growing and declining during different time periods concerning the females' representation (C. C. Hayes, 2010b).

Thus, over time, research has identified several critical issues emerging from the unequal males' and females' participation in CS (Ashcraft, Eger, & Friend, 2012; Barker & Aspray, 2006; Gürer & Camp, 2002) and specifically: (a) the huge demand for people trained in CS in the US (Soper, 2014) and the EU (Hüsing et al., 2013), (b) the need for a diverse workforce to innovate high quality technologies (Margolis & Fisher, 2003), (c) the need for diversity in the population of the designers and the developers of the CS products which become critical and touch the daily lives of the general population (C. C. Hayes, 2010b; Hill et al., 2010), (d) the necessity of advancement of the so-called 'computational thinking' skills for the whole population (Ashcraft & Breitzman, 2007; Barker & Aspray, 2006) and finally, (e) the goal of equal opportunities of both genders in the field (Barker & Aspray, 2006).

As for the reasons for the under-representation of women in CS, it has been an issue of interest for many decades. Research has identified several key social and structural factors affecting women's participation in CS, often deterring them from choosing future CS education or careers in CS, revealing that the reasons for such low participation are multilayered (Ashcraft et al., 2012; Barker & Aspray, 2006; Gürer & Camp, 2002). Females' perceptions, interest, confidence, attitudes, and career decisions are shaped by the larger environment they learn about the field of CS, preventing them from being able to make a truly free choice. Especially, school education, role models, and stereotypes about the field and females' abilities in CS seem to be among those crucial factors that influence girls' final decisions for studying and pursuing CS.

Regarding education, irrelevant curriculum with no connection to real life, teaching practices that discourage collaboration and teachers with (un)conscious bias about girls' abilities, plus the culture of the field may deter girls, even boys, from pursuing CS (Goode, 2007; Lasen, 2010; Margolis, 2010). Moreover, the uncomfortable, unwelcome environment in a CS class, dominated by boys, reinforces the loss of girls' interest (Cohoon & Aspray, 2008; Gürer & Camp, 2002). On the contrary, the presence of a female Computing teacher in class could inspire girls, improve their self-efficacy, and reverse negative stereotypes as they can realize, through real life examples that they themselves can pursue, persist and succeed in CS (Gürer & Camp, 2002).

Concerning stereotypes, there is evidence that one novel and powerful social factor that may perpetuate the under-representation of women in CS is the stereotypes about the culture of the field, which in some cases act as 'educational gatekeepers', discouraging them from entering the field (Cheryan, Master, & Meltzoff, 2015). The image of a computer scientist is one of a genius male computer hacker who spends a great deal of time alone on the computer, has an inadequate social life, and enjoys hobbies involving science fiction. These stereotypes are dominant in our society and students tend to espouse them. Those girls, even boys, therefore, who feel out of that culture, abandon the idea of pursuing CS (Alkhadrawi, 2015).

Beyond the stereotypes about the culture of CS, females also face negative stereotypes about their abilities in CS, making them feel like they do not fit well in the field (Alkhadrawi, 2015). These negative stereotypes are based on some socially constructed 'myths' about gender differences in cognitive skills and academic ability, not only in CS but also in related disciplines in STEM fields. Even though there is evidence mainly from the STEM fields (Britner, 2008; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Jacobs, 2005; Kıran & Sungur, 2012; Matthews, Ponitz, & Morrison, 2009) and CS (Ilias & Kordaki, 2006) indicating that these 'myths' are not real in a scientific and empirical sense in terms of actual measures of ability and performance, they have real social implications as they constitute obstacles discouraging females from engaging into CS and STEM fields. Thus, although there are no gender differences in cognitive skills and ability, people still believe in and behave in response to the belief of such gender differences (Alkhadrawi, 2015). These stereotypes appear to affect females' self-competence, self-efficacy beliefs and motivation and eventually their performance as the latter is closely related to those beliefs (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). In fact, those students who believe that they have the ability to accomplish a particular task, perform better and are more motivated to select increasingly challenging tasks, while expectancies of success (such as self-efficacy) are critical issues in educational and career choices (Bandura, 1986). Females are inclined to have low self-efficacy and think they have little natural ability in male-dominated fields, such as CS and STEM.

However, even though there are no significant differences in performance between males and females in the STEM fields, research suggests that there are some differences in course preferences within each domain (Alkhadrawi, 2015; Amelink, 2009; Pustjens, Van Damme, & De Munter, 2008). Actually, course selections within STEM fields reveal certain persistent differences in preferences (Alkhadrawi, 2015). It seems that, once again, self-efficacy beliefs, along with interest and confidence, influence students' course choices within science fields and their latter decision to major in a field (Beyer, 2014).

Students' decisions on studying and pursuing a specific field are also affected by their learning experiences. Stereotypes about gender ability differences in CS+STEM fields, or about the traits of these fields and their suitability for males and females, communicated from important socializers can influence students' interpretations of their learning experiences (Alkhadrawi, 2015). In that sense, teachers with their practices in class, as important socializers and sources of authority and expertise, are likely to exert a powerful influence on students' expectancy and value beliefs (Gürer & Camp, 2001).

To that end, teachers' practices in class and the factors that shape their behavior are an issue of research especially in STEM fields (Davis & Andrzejewski, 2009; Kang & Wallace, 2005; Mansour, 2009, 2013). A great deal of empirical evidence has established the significance of beliefs for understanding teachers' behavior (Calderhead, 1996; Pajares, 1992; Wittrock, Clark, & Peterson, 1990). In particular, regarding their interactions with girls/boys in class, teachers' gender-related beliefs have been an issue of excessive research within STEM fields (de Kraker-Pauw, van Wesel, Verwijmeren, Denessen, & Krabbendam, 2016; Garrahy, 2003; Ghosh, 2004; Li, 1999; She, 2000; Tiedemann, 2000a, 2000b, 2002; Vekiri, 2010; Watson et al., 2015). Research clearly shows that teacher differential conceptions of their girls' and boys' abilities are translated into gendered classroom practices (Garrahy, 2001, 2003; Li, 1999; She, 2000). As for STEM teachers, it seems that they interact more frequently with boys (Li, 1999; She, 2000), tend to favor male students even when they think that their behavior is gender neutral (Garrahy, 2001), and provide more academic feedback to boys (Duffy, Warren, & Walsh, 2001). Especially male STEM teachers, appear to hold stronger implicit gender-related beliefs linking boys to STEM abilities (de Kraker-Pauw et al., 2016).

1.2 Statement of the Problem

Despite the excessive research regarding the representation of females in CS higher education in several countries, systematic research for the gender representation in the Greek CS education has not been carried out till now. Research for a certain period of time in Greek secondary[1] and tertiary[2] CS education could justify the existence or the absence of the gender gap and possible dynamics, while a cross sectional analysis with the gender representation in related STEM disciplines would reveal the extent of the problem of the female under-representation in Computing. Moreover, such a study would clarify whether there are enough female Computing teachers in secondary education who could motivate girls to pursue Computing, and female faculty in Computing higher education to inspire females and make them realize, through real life examples, that they can persist and succeed in Computing.

In addition, little emphasis has been given to males' and females' actual performance in CS courses in higher education so far and the 'myth' about females' lack of abilities has not been fully challenged. Particularly, there are no studies investigating males' and females' course selections in CS that would uncover males' and females' preferences of specific domains within CS.

Finally, research on Computing teachers' gender-related beliefs have not been reported since in relevant studies in the STEM fields, Technology is approached as a generalized field, under the term ICT (Information and Communication Technology) e.g.

[1] *Computer Science in Secondary Education in Greece* concerns not only Computer Science (CS) as a scientific discipline yet it refers to the whole curriculum related to the development and the use of technology with regard to computers within the context of Information and Communications Technology (ICT) and Digital Literacy (DL). Thus, for the purpose of this thesis, concerning the Secondary Education in Greece, the term *'Computing'* is mainly used referring: (a) to the whole curriculum covering CS as a scientific discipline as well as ICT and DL, and (b) the schoolteachers who teach that curriculum.

[2] *Computer Science in Tertiary Education in Greece* covers both Computer Science (CS) and Computer Engineering (CEng) studies. Hence, for this thesis, the term *'Computing'* is utilized referring to CS and CEng studies in Tertiary Education in Greece.

(Ertmer, 2005; Varma, 2009; Vekiri, 2010). In that sense, research till now has not focused on CTs' gender related beliefs, who actually teach Computing, but only on those teachers who use technology and computers as a tool in class. Given the influence that Computing teachers can exert over students' engagement in Computing, their gender-related beliefs and practices in a CS class is an issue that merits attention, therefore, it is worth examining.

Hence, it could be convincingly argued that it would be of great interest to research: (a) the gender representation in Greek Computing education, (b) males' and females' performance and preferences in Computing, (c) Computing teachers' gender-related beliefs and practices. The '*Problem State'* is discussed in detail in Chapter 4 of this thesis.

1.3 Purpose of the Study

Building on the above, the aim of this thesis is threefold:

Aim1 **–** to examine the gender representation both in Greek Computing secondary education, in terms of Computing teachers (sub-aim 1.1) as well as in Greek tertiary Computing education regarding students/graduates (sub-aim 1.2) and faculty members (sub-aim 1.3) as well as to compare it to the gender representation in the related disciplines of STEM education,

Aim2 **–** to investigate gender differences in preferences (sub-aim 2.1) and performance (sub-aim 2.2) in undergraduate Computing courses,

Aim3 **–** to study Computing teachers' gender-related beliefs (sub-aim 3.1) and practices in terms of interactions with girls/boys in a Computing class (sub-aim 3.2) and uncover possible associations between their expressed beliefs and their actual practices in class (sub-aim 3.3).

1.4 Research Questions

To successfully accomplish the three aforementioned goals, the research questions that this thesis sought to answer are presented below for each of the aims .

Please note that the abbreviation used for each research question has the form RQX.J.I where ‘RQ’ stands for ‘Research question’, ‘X’ stands for each of the aims of the study (Aim 1, Aim 2, Aim 3), ‘J’ stands for each of the sub-aims, if exists, of each aim of the study (sub-aim 1, sub-aim 2, sub-aim 3), ‘I’ stands for the number of the RQ at hand (i, ii, iii). For example, ‘RQ1.2.i’ means research question ‘i’ for the fulfillment of the Aim 1 and its sub-aim 2.

Aim 1

- What is the schoolteacher gender representation in Computing and related STEM disciplines in secondary education during a whole decade (2003–2012) in Greece? (**RQ1.1.i**)
- What is the comparison between the female Computing teachers representation with the female teachers representation in related discipline in STEM secondary education during the decade 2003–2012 in Greece? (**RQ1.1.ii)**
- What is the student gender representation in Computing and related STEM disciplines in tertiary education during a whole decade (2003-2012) in Greece in terms of undergraduate (freshmen, graduates) and graduate studies (master’s degree graduates and PhD’s)? (**RQ1.2.i**)
- What is the comparison between the female student representation in Computing with the female student representation in related disciplines in STEM tertiary education during a whole decade (2003-2012) in Greece in terms of freshmen, graduates, master degree graduates and PhDs? (**RQ1.2.ii**)
- What is the faculty gender representation in Computing and related STEM disciplines in tertiary education during a whole decade (2003-2012) in Greece in terms of professors, associate professors, assistant professors and lecturers? (**RQ1.3.i.**)
- What is the comparison between the female faculty representation in Computing with the female faculty representation in related disciplines in STEM tertiary education during a whole decade (2003-2012) in Greece, in terms of professors, associate professors, assistant professors and lecturers? (**RQ1.3.ii**)

Aim 2:

- What are males' and females' course preferences in a CS department? **(RQ2.i)**
- What is males' and females' performance in courses included in a CS department's curriculum? **(RQ2.ii)**

Aim 3:

- What are Computing teachers' gender-related beliefs with regard to Computing and Computing education? **(RQ3.i)**
- What are Computing teachers' practices with girls/boys in a Computing class in terms of verbal/non-verbal interactions? **(RQ3.ii)**
- What is the relationship between Computing teachers' expressed gender-related beliefs and their actual practices in class with regard to the student gender? **(RQ3.iii)**

1.5 Description of the Research Methodology

The research methodology designed followed the theoretical concept of *"The Research Onion"* (Saunders, Lewis, & Thornhill, 2009). For each of the aims of the present thesis, an individual study was designed to meet the objectives set. For the first aim of this thesis (aim 1) an embedded-single case study (*'Study1'*) was designed exploiting quantitative time-series secondary data for the period from 2002 to 2013 from the Hellenic Statistical Authority (ELSTAT). The data from this longitudinal study were analyzed quantitatively and the results uncovered the gender representation in Computing and STEM education in Greece. Regarding the next aim of the present thesis (aim 2), a holistic-single case study (*'Study2'*) was planned using quantitative data. This second study is cross-sectional research; it investigates an individual case in the Greek Tertiary CS Education, thus, the data employed were secondary data derived from the official records of a CS department (dept) in Greece concerning graduates' course choices and grades of this dept for a considerable amount of time. The data were analyzed quantitatively and the results emerged shed light on gender difference in course choices and performance. For the final aim of this thesis (aim 3), a holistic-single case study

(*'Study3'*) was also designed employing both qualitative and quantitative research methods. It is a cross-sectional study employing mixed primary data collection methods; non-standardized/semi-structured interviews/one to one/face to face interviews with Computing teachers to elicit their gender-related beliefs and structured observations to study their actual practices in class. The selection of the sample for this study was based on convenience sampling, while the data from the interviews were first analyzed *qualitatively* and subsequently *quantitatively*, whereas data emerged from the observations were *quantitatively* analyzed. The '*Research Methodology'* is further discussed in Chapter 4 of this thesis.

1.6 Significance of the Study

A thorough examination of the threefold aim of this study would definitely provide useful insights into: (a) gender gap in Greek Computing education in terms of secondary school teachers as well as students and faculty members in Computing higher education, (b) gender differences in performance and preferences in CS courses in higher education, and (c) Computing teachers' gender-related beliefs and practices.

The systematic investigation of gender representation in Greek CS education would draw a clear picture of the gender gap in Greece and reveal possible dynamics in females' recruitment and retainment in CS tertiary education, while the cross-sectional analysis with the female representation in related disciplines included in STEM education would definitely uncover the extent of the problem of the female under-representation in Computing compared to other STEM fields in Greece. Given that no other systematic studies have been conducted in terms of gender representation in Greek secondary and tertiary Computing education, it is hoped that the results of this study could be exploited by researchers and educators in the field so as to be aware of the representation of women in Computing and take appropriate actions. The investigation of the representation of female secondary teachers and faculty members would reveal whether there are enough female role models who could become female students' mentors recruiting and retaining them in Computing.

Moreover, the analysis of the gender differences in performance in CS courses would challenge the myth about differences in cognitive skills and academic ability in

Computing between males and females, while the examination for the first time of student course selections in Computing could reveal males' and females' preferences of specific domains within Computing. As a result, this study could contribute both to the field of CS curriculum and instruction so as to remove perceived boundaries within certain CS career paths and may lead to the modification of the CS curriculum and instruction by CS teachers in order to adjust the context of CS to both males' and females' preferences and interests .

Finally, the empirical investigation of Computing teachers' gender-related beliefs and their relationship with their actual (gendered) teaching practices in class would uncover whether teachers' beliefs stem from stereotypes about gender differences in CS and guide their practices by affecting female students' engagement in Computing. Since this is the first empirical study in Computing teachers' gender-related beliefs and practices it is hoped that the results emanating may offer valuable information to researchers in the field and challenge Computing teachers reflect on their (gendered) teaching practices, becoming aware of their beliefs regarding gender and Computing.

1.7 Clarification of Terms

Within the context of this thesis two terms, *'Computer Science'* and *'Computing'* are utilized. The primary distinction between '*Computing'* and '*Computer Science'* relates to the purpose they serve. In particular, *'Computing'* is defined by the ACM Computing Curricula 2005[3] as follows:

> "In a general way, we can define Computing to mean any goal-oriented activity requiring, benefiting from, or creating computers. Thus, Computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; doing scientific studies using computers; making computer systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on. The list is virtually endless, and the possibilities are vast."

3 The Joint Task Force for Computing Curricula 2005. "Computing Curricula 2005: The Overview Report" (PDF). Archived from the original (pdf) on *15-08-219*.

Computing entails five sub-disciplines: Computer Science, Computer Engineering (CEng), Information Systems (IS), Information Technology (IT), and Software Engineering (SE)[4]. Concerning education, the term *'Computing'* refers to the whole curriculum related to the development and the use of technology with regard to computers. The constituent parts are Computer Science, Information and Communications Technology (ICT), Digital Literacy (DL) as well as Technology Enhanced Learning (TEL) (Computing at School Working Group, 2012). Computing does teach a pupil how to be an effective *author* of computational tools (Computing at School Working Group, 2012).

On the contrary, *'Computer Science'* is a quintessential STEM discipline, sharing attributes with Engineering, Mathematics, Science, and Technology. It provides student with insights into the other STEM disciplines, and with skills and knowledge that can be applied to the solution of problems in those disciplines. CS is a discipline

> "…that seeks to understand and explore the world around us, both natural and artificial, in computational terms. … It concerned with the study, design, and implementation of computer systems, and understanding the principles underlying" (Computing at School Working Group, 2012, p. 5).

For the rest of this thesis, the term *'Computer Science'* is used referring to the scientific discipline, and it is utilized accordingly in the chapters of the literature review as well as in the context of *Study2* of this thesis, which clearly refers to CS studies. By contrast, the term *'Computing'* is used as a broader term, including CS. It is employed correspondingly both in the literature review section and the research part of the present thesis, especially in *Study1* and *Study3*.

1.8 Outline of the Thesis

The present thesis is divided into four sections:

Section A – *Literature Review* lays the theoretical background of the study and comprises two chapters:

Chapter 2 – *Gender Issues in CS* presents a critical review of the literature in the field of gender and CS. Emphasis is placed upon the gender gap in CS in higher

4 *"Curricula Recommendations"*. Association for Computing Machinery. 2005. *Retrieved 15-8-19)*

education and workforce, the need to fill this gap as well as the key factors affecting females' participation in CS, deterring them from entering the field.

Chapter 3 – *Teachers' Beliefs and Practices* offers an overview of teachers' beliefs, underlying not only the impact these beliefs may have on teachers' decisions in the educational setting but also their actual classroom practices. In particular, resorting to relevant literature, emphasis is placed upon teachers' gender-related beliefs and practices and their effect on females students' motivation and decisions to study and pursue Computing.

Section B – *Research: Problem State and Research Methodology.* This section consists of one chapter:

Chapter 4 – *Problem State and Research Methodology* specifies the open research issues identified in the literature review, defines the purpose of the thesis and sets up the research questions that need to be explored and eventually answered by this thesis. In addition, the research methodology is described.

Section C – *Research: Data Collection, Data Analysis and Results* is aimed to present the research techniques and procedures (data collection and data analysis) followed as well as the research results for each study designed to fulfill the aims of this thesis. It consists of three chapters:

Chapter 5 – *Gender representation in Computing Education in Greece* approaches the first aim of this thesis and offers a detailed presentation of the gender representation in Computer Science and STEM education in Greece in terms of teachers in secondary education as well as students/graduates/faculty members in tertiary education.

Chapter 6 – *Gender differences in preferences and performance in Computer Science Education* aims to fulfill the second aim of this thesis and presents the investigation of gender differences concerning both undergraduate preferences and performance in CS undergraduate courses.

Chapter 7 – *Computing Teachers' Gender-related Beliefs and Practices* is concerned about the research that conducted within the context of the third aim of this thesis. It provides a presentation of the analysis of the interviews and the observations in order not only to elicit CTs' gender-related beliefs but also examine their actual practices in class, revealing certain teaching profiles. The synergies between beliefs and practices are also discussed in this chapter.

Section D – *Discussion and Conclusions* offers a substantiated discussion and interpretation of the research findings. It includes one chapter:

Chapter 8 – *Discussion, Conclusions, Implications and Future Research Dimensions* brings together all the issues researched in this work in an attempt to fulfill the threefold aim of this study, draws conclusions and highlights the importance and implications of the final results. Additionally, the limitations of the research are acknowledged along with recommended areas for future research that may be inspired or might be a natural consequence of the present work.

List of Appendices – *Appendices I,II, and III* present all the supplementary material for Studies 1, 2, and 3 of this thesis correspondingly.

1.9 List of Published Papers

Book chapter

BC1. Kordaki M., & **Berdousis** I. (2019) Gender Differences in Computer Science Departments. In: Tatnall A. (eds) *Encyclopedia of Education and Information Technologies*. Springer, Cham. First Online: 11 June 2019, DOI: https://doi.org/10.1007/978-3-319-60013-0_184-1, Online ISBN: 978-3-319-60013-0

Papers in referred international journals

J3. **Berdousis**, I., & Kordaki, M. (2019). Gender and student course preferences and course performance in Computer Science departments: A case study. *Education and Information Technologies, 24*(2), 1269-1291.

J2. **Berdousis**, I., & Kordaki, M. (2018). Computing and STEM in Greek tertiary education: gender representation of faculty members during the decade 2003–2013. *Gender and Education, 30*(1), 1-21.

J1. Kordaki, M., & **Berdousis**, I. (2017). Computing and STEM in Greece: Gender representation of students and teachers during the decade 2002/2012. *Education and Information Technologies, 22*(1), 101-124.

Papers in referred national journals

JG1. **Berdousis,** I., & Kordaki, M., (2013). The distribution of Computing teachers in Greek Education in the decade 2003-2012: the gender dimension. *Themes of Science and Technology in Education*, *6*(3), 117-135.

Publications in proceedings of international conferences

C4. **Berdousis**, I., & Kordaki, M. (2015). Female faculty at Greek Computing Departments: 2003-2012. In (L. Gómez Chova, A. López Martínez, I. Candel Torres Ed.) Proceedings of *9th International Technology, Education and Development Conference (INTED 2015)*, 2-4 March 2015, Madrid Spain (pp. 0785-0792). IATED Academy ISBN: 978-84-606-5763-7, ISSN: 2340-1079. (included in ISI Conference Proceedings Citation Index CPCI (Web of Science).

C3. **Berdousis**, I., & Kordaki, M. (2014). Achievement in CS Courses: Gender Issues. In L. Gómez Chova, A. López Martínez, I. Candel Torres (Ed.) Proceedings of *8th International Technology, Education and Development Conference (INTED 2014)*, 10-12 March 2014, Valencia, Spain (pp. 6617-6623). ISBN: 978-84-616-8412-0, ISSN: 2340-1079, (included in ISI Conference Proceedings Citation Index CPCI (Web of Science).

C2. **Berdousis**, I., &Kordaki, M. (2014). Gender Differences and Achievement in CS: a Case Study. In Proceedings of *6th World Conference on Educational Sciences*, 06-09 February 2014, University of Malta, Malta, Procedia - Social and Behavioral Sciences, Volume, 191, 2 June 2015 (pp. 1161-1166).

C1. Kordaki, M., & **Berdousis**, I. (2013). Course Selection in CS: Gender Differences. In Proceedings of *5th World Conference on Educational Sciences*, 05-8 February 2013, Sapienza University of Rome, Italy, *Procedia - Social and Behavioral Sciences*, Volume, 116, 21 February 2014 (pp. 4770-4774).

Publications in Proceedings of National Conferences (in Greek)

S1. **Berdousis**, I., & Kordaki, M. (2014). Computer Science students in Greek Tertiary Education: gender issues. In Proceedings of *7th Pan-Hellenic and International Conference 'Didactics of Informatics'*, ETPE, Dept. of Primary education, 20-22 April 2014, Rethymno, Greece (pp. 150-160).

Section A. Literature Review

Chapter 2.

Gender Issues in Computer Science

Summary: This chapter presents an overview of the literature in the field of gender and Computer Science (CS). It highlights the female under-representation in CS in several countries and documents the need to fill the gender gap in CS studies and the workforce. It also identifies the key factors-barriers affecting females' participation in CS, deterring them from entering the field.

2.1 Female Representation in Computer Science

People think of Computer Science as a recent discipline. In essence, the word 'computer' has been in use since before the early 17th century when it referred to a person performing computations[5]. In fact, CS was an important skill for many mathematicians who relied on automation and programming as far back as 100 B.C. CS evolved from the discipline of math but as electronic computers became accessible to the public, CS started to be recognized as a valid discipline on its own[6]. In the early 1960's, CS depts started to split themselves out from math depts and the first actual bachelor's degree in CS being awarded at Purdue in 1962[7].

Women have been pioneers in the evolution of CS, and their stories need to be known more widely. They have passionately programmed computers for many decades. As far back as 1843, Ada Lovelace wrote programs on Charles Babbage's mechanical computer while in 1946 six women mathematicians, known as human 'computers' -Fran Bilas, Betty Jennings, Ruth Lichterman, Kay McNulty, Betty Snyder, and Marlyn Wescoff- created working programs for the ENIAC computer during the Second World War. Even later, Grace Murray Hopper played a key role in creating COBOL and standardizing FORTRAN - named as the Data Processing Management Association's first 'man of the year' in 1971 (Misa, 2010a).

According to Misa (2010b), in the 1950s the pioneering generation of CS featured a surprising number of prominent women who led research teams, defined computer languages and even pioneered the history of CS. In the 1960s, women entered the emerging CS profession in unusually large numbers. Women played a crucial role in the establishment of CS, especially in programming which, unlike to other technological fields, was a field open to females.

In 1970s, 22.5% of CS programmers were women (Ensmenger, 2010). In mid-1980s, women earned 37% of all U.S. bachelor degrees in CS, and across these decades women constituted about the 38% of the U.S. 'white-collar' CS workforce (systems

5 https://en.wikipedia.org/wiki/Human_computer
6 https://en.wikipedia.org/wiki/Computer_science
7 https://www.cs.purdue.edu/history/history.html

analysts and software developers). Actually, CS field grew rapidly from an esoteric field of study in the mid-1960s to a popular major by the mid-1980s, only 20 years later.

Despite these early successes, in the late-1980s women stop entering CS in large numbers, and the proportion of women studying CS actually began falling dramatically - and it has continued to do so, steadily, until to date (Camp, 2012).

As a matter of fact, CS changed more rapidly than most STEM disciplines concerning the number of women (Misa, 2010a). The number of females in CS has been falling since the mid-1980s (turning point) while most other disciplines continued to increase their representation of women. Abbate (2010) attributes this fact to the entry requirements that CS departments instituted, which ultimately favored males, in an attempt to reduce the number of their students, while C. C. Hayes (2010a) claims that unattractive stereotypes about CS scientists started to become established, affecting more females than males. Thus, the percentage of CS undergraduate degrees awarded to women in the US has been decreasing since the mid-1980s' from a high of 37.1% to a low of 17.8% in 2012 with a consistent descending trend (Camp, 2012). Camp (2012) highlights that this descending trend is unique in CS by listing data, indicating that the proportion of undergraduate degrees awarded to women in all disciplines has increased the last decades reaching to a high of 57% in the US in 2012. The percentage of undergraduate degrees awarded to women in biological/life sciences, engineering, and physical sciences increased by 26.5%, 40.6%, and 47.8% respectively (Camp, 2012). More precisely, 52% of all math and science undergraduate degrees and 42% of all math degrees have been awarded to women in 2012. It was in 1997 when Camp noticed the problem, acknowledging its 'uniqueness' and predicted that within the next years the total number of CS degrees would increase as well as the percentage of the degrees awarded to women both due to the vast development of CS and the huge need for computer scientists (Camp, 1997). In a later survey (Camp, 2012), however, she ascertains that the problem of the representation of women in CS is still present.

C. C. Hayes (2010a) draws on existing data sets from the National Science Foundation in U.S. and several longitudinal surveys to present a larger picture of CS female representation in the U.S. These data reveal a complex and multilayered picture of CS. C. C. Hayes (2010a) shows that there are *'distinctive trajectories and dynamics'* at the undergraduate level compared to the graduate level. Although women's participation at the graduate level (master's and doctoral degrees) has still been low, there has been a slight increase across the decades. It is at the undergraduate level (bachelor's degrees) where, since the 'turning point' in the mid-1980, the proportion of women earning CS degrees constantly has declined. Compared to other STEM disciplines, in which the proportion of women has steadily increased, CS seems to be a field of extremes, being both the fastest growing and declining during different time periods concerning women representation (C. C. Hayes, 2010a).

In addition to the above, C. C. Hayes (2010a) presents data suggesting that women's participation in the CS workforce is falling off too –and possibly even faster than CS enrollments might predict. C. C. Hayes (2010a) convincingly argues that even if the proportion of women in workforce (in every field) has steadily increased, equal numbers may not mean equal status mainly due to the fact that fewer women, who are promoted more slowly and paid less, hold management and leadership positions. In fields like CS, where women are scarce, the number of women in high leadership roles is very small.

Historically, women did hold positions of lower status and payment. Haigh (2010) identifies the status of women as data-entry workers who were generally not able to enter professional positions as data processing supervisors and systems analysts jobs occupied most often by men. Schlombs (2010) maintains that women were relegated to the boring tasks of data entry in key-punch operations, establishing what became a *'persistent pattern of female (non)participation in Computing*'. Hicks (2010) explains that in Great Britain '*Computing was first institutionalized as a feminized sphere of work, and then very self-consciously re-engineered as a field of masculine endeavor*. Along the same line, the study of Ensmenger (2010) about the cultural perceptions of programming indicates that the American Computing industry privileged masculine talents as opposed to the detailed *''hand-work' of the (largely female) 'coder''* (p. 123). Downey (2010) claims that library science, recognized for some time as an *'intelligent woman's profession in a numerical sense, was also a gendered profession in an analytical sense'* as women earned less, held less powerful positions, and were occupied with 'technical services' and 'public services'. Men and women were present in CS workforce history but were clustered in different occupations. Occupations with less status were assigned mostly to women. Moving up the salary ladder -from keypunch workers (at the bottom), through computer operators, programmers, and (at the top) systems analysts-there is a remarkable consistency in that '*the proportion of women drops and the average pay rises*.' (Haigh, 2010).

Eventually, C. C. Hayes (2010a) provides clues about the trend of female participation in the CS workforce, highlighting that this follows a pattern similar to that in undergraduate CS education, especially for 'white-collar' professions (systems analysts and software developers). Despite the shrinking representation of females in undergraduate studies and in CS workforce, the proportion of women at higher ranks - doctorates and faculty- have continued to grow overall.

The under-representation of females in both CS education and the workforce in several countries, has motivated excessive research, documenting the necessity of increasing females' representation and identifying those essential factors influencing females' participation in CS.

2.2 Why we need Women in Computer Science

Research has identified several reasons to justify why increasing the participation of women (and other underrepresented groups) in CS is crucial. Camp (2012), advocates that when it comes to the underrepresentation of women, being educated in CS, three critical issues emerge. These issues concern the *labor shortage and huge demand* that exists for people trained in CS (see Section, 2.2.1), the need for diversity in the workforce to innovate higher quality technologies (see Section, 2.2.2) and the goal of equal opportunity (see Section, 2.2.3).

2.2.1 Labor shortage and demand

Despite widespread usage of computers-based technologies, only a small, unrepresentative sample of the population is involved in creating new technologies. Advances in CS enable progress across many disciplines including fields as medicine, education, and predicting natural disasters. As Kelleher and Pausch (2007) notice, '*given* *the broad impact of CS, it is critical that we ensure that CS continues to attract bright minds that will enable the field to continue to make forward progress and support progress in other fields.*' (p. 60).

More precisely, the U.S. is currently not training enough computer scientists and engineers to keep up with demand (Soper, 2014). The lack of female participation in Computing exacerbates the problem with labor supply shortages. In the US, the overall need for CS professionals has severely outstripped the number of graduates entering the workforce (Soper, 2014). Ashcraft et al. (2012) using data from the National Science Foundation state that women make up only 26% of CS professionals in the US. These numbers are even starker when considering that the number of students earning undergraduate degrees in CS has been on a downward trend and has decline (Camp, 2012). What is more, the number of jobs that require computer specialists has significantly increased. The U.S. Bureau of Labor predicts that employment in the information sector, which contains fast-growing computer-related industries, is strong[8]. Specifically, the U.S. Department of Labor estimates that between 2010 and 2020 there will be more than 1.4 million Computing-related job openings available in the US. Ashcraft et al. (2012), estimate that, as far as the US is concerned, at current college graduation rates in CS, they can only fill 32% of those jobs with U.S. CS graduates.

Likewise, the great need of computer scientists is a reality for EU as well. Hüsing et al. (2013), report that the CS workforce in Europe has been growing over the past decades and will continue to grow in the future. There has been a steady increase in the number of ICT practitioners in the workforce and there is no indication that this trend will change. They claim that even at the times of the economic and financial crisis, which Europe is undergoing since late 2008, the annual growth of CS employment has remained very robust. The labor market seems to absorb all CS graduates even through the crisis. Despite that fact, they note that interest in pursuing CS careers seems to be diminishing among younger generations in EU. The number of CS graduates was growing in the past but has been in continuous decline in Europe since 2005. Even more, the speed of decline is what makes the situation rather dramatic with the number of CS graduates from

8 http://www.bls.gov/opub/mlr/2012/01/art5full.pdf

university decreasing even more drastically than expected. Hüsing et al. (2013) conclude that to date demand for CS and ICT workers is outnumbering the supply. They also estimate that future demands will increasingly occur in higher level CS jobs including the management, planning and strategy and CS development specialist occupations and less in Computing support, delivery and operation, i.e. infrastructure type occupations. According to their scenario, the CS workforce will grow from 6.53 million in 2011 to 7.09 million in 2020, while the excess demand or shortage amounts 889,000 in 2020. There is clearly a need for increasing the number of people entering CS.

When it comes to female in CS, their underrepresentation is also an alarming issue for the EU. According to a report from the European Commission[9] (EC), in the EU there are now too few women working in the ICT sector. Of 1,000 women with a Bachelors or other first degree, only 29 hold a degree in CS (as compared to 95 men), and only 4 in 1000 women will eventually work in the Computing sector. Additionally, women are far more likely to leave the sector mid-career. Women also struggle to reach the top roles (managerial and decision-making positions) in firms in the sector. What is more, only 19.2% of Computing-sector workers have female bosses, compared to 45.2% of non-Computing workers.

Young women appear to bring great potential for filling the gaps in US and EU, yet to date; many factors dissuade them from choosing CS majors and careers. As Camp (2012) explains if we do not boost the participation of women (and other minorities), then the growth and sustainability of the CS field will be in serious jeopardy

2.2.2 Need for Diversity

A sizable, diverse and creative Computing workforce is critical for continued participation in the high-tech, global economy (C. C. Hayes, 2010b). Failing to capitalize on the talent of women in CS may threaten productivity, innovation and competitiveness (Ashcraft et al., 2012; Hill et al., 2010) .

2.2.2.1 Productivity. Diversity improves productivity. This fact is true not because women (and minorities) are better or smarter than non-minority men or vice

9 http://ec.europa.eu/digital-agenda/en/news/women-active-ict-secto

versa but because diverse groups bring diverse experiences to the table. These diverse experiences mean that the diverse team at the table will ask different questions, which serves to indicate that the products and services developed will be of higher quality (Camp, 2012).

In essence, research reveals that under the right circumstances diverse teams improve creativity, problem-solving and productivity (Page, 2008). A large study spanning 21 different companies showed that teams with 50:50 gender membership were more experimental and more efficient (DuBow, 2011).

Another study has also shown that groups with greater diversity solve complex problems better and faster than do homogenous groups (Ashcraft & Breitzman, 2007). In particular, this study by the National Center for Women in IT (NCWIT) found that IT patents issued to mixed-gender teams are more frequently cited (26 to 42% more) than similar IT patents submitted by an all-male team or an all-female team. What is more, a 2014 report from NCWIT[10] pointed out that work teams with equal male and female membership have been shown to be more experimental and more efficient than single-sex teams, all male or all female. Additionally, when women have engaged in CS, they have been able to create high-tech start-ups with less funding and fewer failures than the average.

2.2.2.2 Innovation. Computer Science is a field created by innovative thinkers whose products and systems have become critical and touch the daily lives of a broad segment of our population. Ideally, these technologies should be developed by a population as diverse as its users. Increasing the diversity of viewpoints in CS may help to ensure that we design new technologies that meet the needs of our diverse society. As a society, we lose out on potential innovations when we do not have a diverse workforce fully participating in technology creation (Doz, Santos, & Williamson, 2004).

Actually, a diverse workforce reflects the customer base. Most companies serve a variety of people, so it makes sense to have a variety of intelligent, skilled people working on services and products. Products and services that are developed by a diverse team means that these are being created for everyone. Technologies designed by an

10 https://www.ncwit.org/resources/ncwit-scorecard-report-status-women-information-technology

unrepresentative group may be less likely to take everyone's needs into account. For example, early voice activated systems only worked for men, as women's voices were literally unheard during the development (Margolis & Fisher, 2003). The failure to recognize women's voices is likely the result of the voice recognition and video conferencing teams testing their programs with their male-colleagues. A more diverse design team decreases the likelihood that this kind of scenario will occur.

Furthermore, the problems that we choose to solve and the technologies that we create inevitably reflect our personal beliefs about what kinds of problems are important and how they should be solved. As technology continues to become an integral part of daily life, involving a representative sample of people in the design of new technologies can help ensure that our technologies meet everyone's needs. We need to ensure that the future technology we design is as broad and innovative as the population it serves (Ashcraft et al., 2012; Barker & Aspray, 2006).

Beyond the need to reflect the customer base, diversity can boost innovation. There is some evidence suggesting that men and women would tend to design different kinds of technologies. A study of 47 boys and girls showed that when they were asked to design their 'dream' technology, they tended to describe very different things. Boys often described vehicles that could take them anywhere whereas girls often described objects that could help in everyday life (Cassell & Jenkins, 2000). Similar differences were seen among 24 adult technology users. The men tended to fantasize about bionic mind implants that grant god-like powers whereas the women in the study tended to fantasize about small flexible technologies that help people stay in touch and adapt to the wearers' current needs (Cassell & Jenkins, 2000). Because men and women appear to visualize different future technologies, it seems likely that they will tend to push technology in different directions. If we do not capitalize on the creativity of diverse teams, the needs of our diverse society and future high-quality technical innovations are in serious jeopardy.

2.2.2.3 Competitiveness. Getting more girls interested in a CS career and getting more women into Computing jobs would ensure, as well, a competitive workforce, benefit the Computing industry, women themselves and Europe's economy. The lack of women in Computing roles at tech firms is costing the European economy €9 bn in lost revenue, according to a report from the European Commission (EC)[11]**.** The EC research argued that more women in Computing would mean better performance for companies, as it claimed firms that included women in higher positions '*achieve a 35% higher return on equity and 34% better total return to shareholders*' when compared with other firms. According to the study, if the trend were reversed and women held Computing jobs as frequently as men, the European GDP could be boosted annually by around € 9bn. The EC based the €9bn saving on the assumption that if employment for women in ICT rose by 115,000 roles, an average of €78,000 per female worker would be generated in increased productivity. What is more, women themselves can profit from this career choice by earning higher salaries: females in the Computing sector earn almost 9% more than women in similar positions in the non-Computing service sectors. They enjoy higher flexibility to arrange their working schedules and will be less susceptible to unemployment.

In addition, there are studies indicated that having mixed leaders results in higher financial benefits (Catalyst, 2004; Herring, 2009). Technology companies with the highest representation of women in their senior management teams showed a higher return on equity than did those with fewer or no women in senior management. A recent study determined that gender diversity were associated with increased sales revenue, more customers, and greater profits (Herring, 2009). Another study evaluated the financial performance of 353 companies and concluded that companies with strong representation of women executives deliver 34% higher return to shareholders and 35.1% higher return on equity than companies with the lowest representation of women (Catalyst, 2004)

2.2.3 Equal Opportunities

Attracting more women into CS will not just help to address a problem that risks damaging the whole economy and failing to reflect our diverse society, but also contributes to realizing goals for equal opportunities and empowers women by enhancing their capacity to participate fully in the information society and shape its development

11 http://bookshop.europa.eu/en/women-active-in-the-ict-sector-pbKK0113432/

(Ashcraft et al., 2012). With technology playing an increasingly crucial role in all of our lives, having more people from different backgrounds in its creation can help break down gender inequalities (Ashcraft et al., 2012).

What is more, jobs in the Computing fields are often high-status, lucrative, and flexible (Kalwarski, Mosher, Paskin, & Rosato, 2007), and thus women are missing out on jobs that are potentially beneficial for them. Increasing girls' participation in Computing is important for promoting equity and ensuring that girls are able to take advantage of these jobs and the opportunities they make possible (Barker & Aspray, 2006; Margolis, Goode, & Bernier, 2011).

In addition, studying CS, not only for girls but the whole population, provides a versatile skill set that crosses disciplines and is essential in today's information economy (Camp, 2012). The so-called *Computational Thinking* is a fundamental skill for everyone, not just for computer scientists. Wing (2006) claims that *'to reading, writing and arithmetic, we should add computational thinking to every child's analytical ability*' (p. 33). Computational thinking involve solving problems, designing systems and understanding behavior, by drawing on the concepts fundamental to CS. Open-ended problems encourage full, meaningful answers based on multiple variables, which require using decomposition, data representation, generalization, modeling, and algorithms. Through CS, students are equipped with computational thinking skills that can be applied to a broad range of disciplines ranging from Biology to Sciences, Arts and Economics (Wing, 2006).

2.3 Identifying Barriers: Why Women do not Participate in Computer Science

Over time, several studies have identified numerous key social and structural factors that influence girls' participation in CS, often deterring them from choosing future education or careers in technology (Ashcraft et al., 2012; Barker & Aspray, 2006; Dryburgh, 2000; Gürer & Camp, 2001, 2002).

The following model depicts these key factors (see Figure 1). In the center of this model are placed *Girls' perceptions, interest, confidence, attitudes, career decisions* in order to highlight that these are shaped by the larger environment they learn about the field of Computing precluding women from being able to make a truly '*free'* choice.

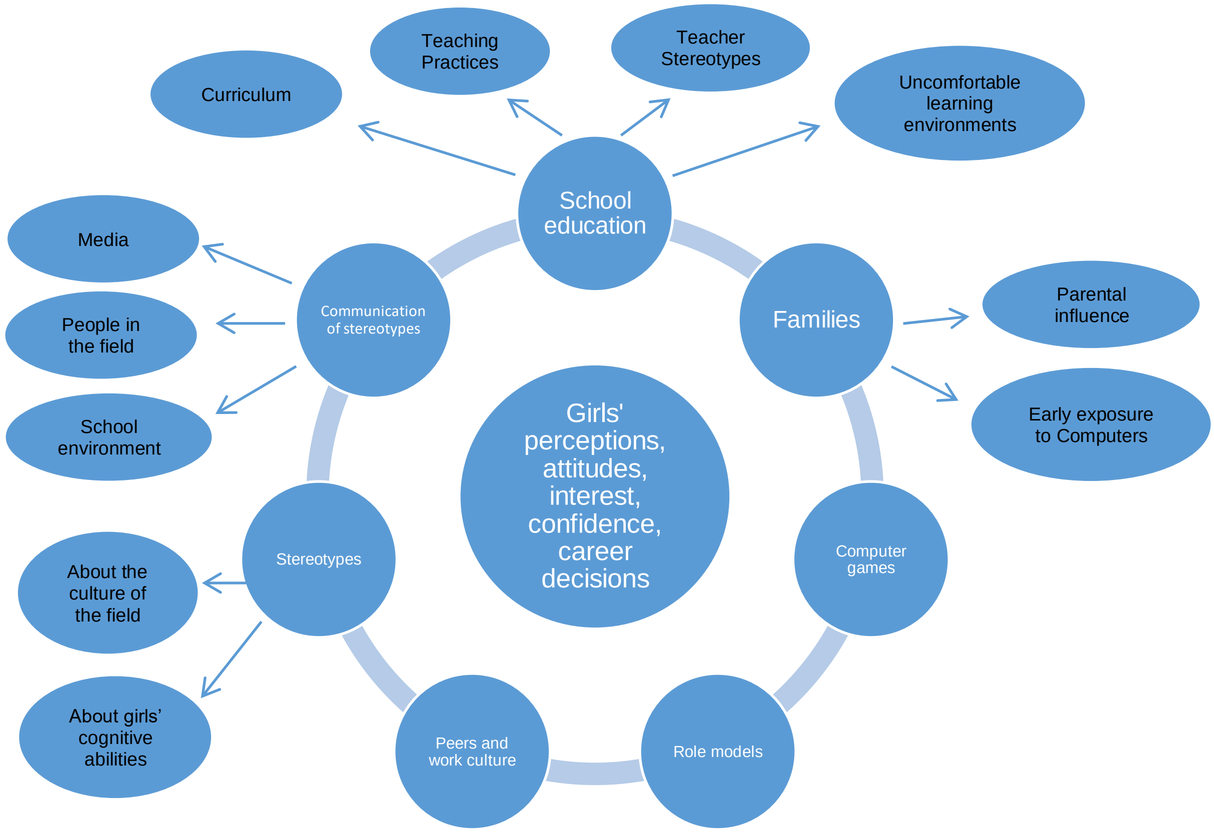


Figure 1. Key factors that influence women's participation in Computer Science

2.3.1 School Education

Educational research based on constructivist, constructionist, and culturally relevant learning theories has emphasized the importance of connecting teaching to students' prior knowledge and interest, as well as using active and collaborative learning pedagogies (Papert, 1980; Vygotsky, 1980). These approaches are important for all students, not just only for improving learning for girls. Recent research has focused mainly on studying whether curriculum and teaching practices in science-related fields, employ or not these approaches and, therefore, contribute to girls' loss of interest in science fields.

Concerning school education, Ashcraft et al. (2012) concluded that there are some key factors contributing to that loss of interest, and not just for girls. These factors are (a) the *curriculum* with no relevant connection, and (b) *teaching practices* that discourage collaboration and do not give the chance to students to take risks or make mistakes, and pedagogies that, mainly, rely on lecturing instead of active, hands-on, project-based learning. The research also point out that, usually, (c) *teacher stereotypes,* and (d) *uncomfortable learning environments* discourage girls' participation fading out their interest.

2.3.1.1 Curriculum. Some studies indicate that CS courses, and the way these are taught, make CS curriculum irrelevant, encouraging negative perceptions, deterring girls from taking these courses (Goode, 2007; Margolis, 2010).

When CS is taught in the abstract, students cannot recognizing how technology can help address social problems. This teaching approach also reinforces a view of CS as a lonely, isolated, machine-focused field (Margolis, 2010; Papastergiou, 2008). The lack of relevance is disconcerting since realizing relevant connections is particularly important for increasing girls' interest in CS courses and careers (Teague, 2002). Relevant curriculum is not an issue just for girls, but actually influences many boys' interests in CS courses.

A study on female secondary students (Anderson, Lankshear, Timms, & Courtney, 2008) also identified two key factors for not taking CS courses: (a) *'the subjects are boring'* (p. 1310) and (b) *'the subjects would not be helpful to me in my chosen career path'* (p. 1310). Interviews with those girls that did not take CS courses revealed that these subjects were perceived to be boring due to their prior experiences in earlier secondary school CS courses. They stated that CS courses had been taught by teachers with limited preparation and consisted of '*mundane, repetitive tasks*' (Lasen, 2010).

2.3.1.2 Teaching practices. *Independent vs collaborative learning*. In Computing classrooms teachers often favor independent work and discourage collaborative work. This is a fact at both the secondary and undergraduate level (Clark Blickenstaff, 2005; Margolis, 2010). In fact, collaboration is important for student learning. There are studies indicating that, for instance, pair programming, advance students' CS skills and improve girls' experiences and interest in CS courses (McDowell, Werner, Bullock, & Fernald, 2002; Werner & Denning, 2009). Research has revealed positive effects of collaboration for girls. Collaboration increased networks of support for girls and increased persistence in debugging challenges (Marcu et al., 2010; Werner & Denning, 2009). Despite the fact that collaboration is crucial, teachers have to ensure that they create the appropriate conditions that result in productive collaborations.

Traditional teaching vs putting CS concepts out of the screen. Teaching practices plays a key role in undergraduate studies too. Rubio, Romero-Zaliz, Mañoso, and Angel (2015) analyzed gender differences in an introductory programming course at the university level. Their results indicate that male and female students have different perceptions and learning outcomes in a traditional introductory programming course: male students find programming easier, have a higher intention to program in the future and show higher learning outcomes than female students. To reduce these differences they designed and implemented several learning modules using the principles of physical CS, in order to take computational concepts out of the screen and into the real world so that students can interact with them. They used electronic board and designed specific modules for lecture demonstration and laboratory sessions. Unlike the control group, where the instructor used traditional methods, in the experimental group the instructor used the physical CS modules in the lectures and in the lab sessions students worked in pairs only when completing the physical CS modules. They evaluated the modules in an introductory programming course and found that they were highly effective. Using these modules the differences in perception and learning outcomes between men and women disappeared.

2.3.1.3 Teacher stereotypes. What is more, teachers often have the tendency to assume that, while girls work hard, boys have innate talent for CS, are more natural with the computer and have more interest (Barker & Aspray, 2006; Margolis, 2010). That unconscious biases about who has a flair on CS are crucial since perceived support from teachers affects girls’ interest in Computing classes and CS careers (Denner, 2011). Teachers’ gender-related beliefs are discussed in detail in the next chapter (see Section 3.4).

2.3.1.4 Uncomfortable learning environments. Societal beliefs about CS as masculine are present and disseminated in Computing classrooms (Margolis, 2010). Computing classroom is often dominated by boys and girls often experience it as an uncomfortable and unwelcome environment (Goode, 2007).

According to Gürer and Camp (2002), girls lose interest in Computing early on, as usually Computing labs are dominated by boys, girls are sidelined, trying to figure out things on their own as boys tend to monopolize the instructor's time. In a Computing environment boys act like 'hosts', attempting to prove their knowledge, and girls like 'guests', leaving space and computer time to boys to gain more experience.

Some males also tend to encourage the creation of uncomfortable and even hostile environments for women. Boys take over the computer lab, show off their skills, tell sexist jokes and make fun of others when they make mistakes. It seems that females feel uncomfortable when forced into these environments (Gürer & Camp, 2002). Typically, classrooms that do not make an effort to provide a gender-neutral atmosphere actually end up promoting a male-oriented domain (Gürer & Camp, 2002).

To sum up, formal education can be a factor contributing to the low representation of females in Computing negatively affecting, in some cases, their interest in the field. Irrelevant curriculum with no connection to real life, teaching practices that discourage collaboration and teachers with (un)conscious bias about girls' abilities and the culture of the field are basic aspects of school education that may deter girls, even boys, from pursuing CS. Moreover, the uncomfortable, unwelcome environment in a Computing class, -dominated by boys- reinforces the loss of girls' interest.

2.3.2 Families

Families seem to play a crucial role in girls' engagement in CS (Ashcraft et al., 2012). The *parental influence*, regarding parental expertise or career in CS along with their support and encouragement, as well as girls' *early exposure* to Computers and Computing at home are considered to be key factors in affecting girls' interest in CS.

2.3.2.1 Parental Influence. Parents have significant influence as role models and in the types of messages or beliefs they communicate to girls both implicitly and explicitly (Liston, Peterson, & Ragan, 2007).

Parental expertise or career in CS can play an important role in influencing girls' perception on the CS field. Some studies indicate that the majority of women working in Computing field reported that a member of their families (in most cases the father) worked in STEM fields (Liston et al., 2007). In the case of high school students (Gal-

Ezer, Shahak, & Zur, 2009) parents' careers were not a significant factor in students' decisions to take CS courses for either boys or girls. Cozza (2011) in a literature review concludes that '*relatives — most often fathers or brothers — who have taken up careers in CS, or who have greater familiarity with the computer, may reinforce the stereotype of technology as masculine*' (p. 323).

On the other hand, research suggests that *parental or familial support and encouragement* to pursue CS seems to be decidedly important. In some cases, parents unintentionally provide obstacles for their own daughters and through subtle biases provide more support for their male children (Gürer & Camp, 2002).

In his study, Barron (2004), found that 75% of girls who had taken a programming class had been encouraged by parents or other family members to take the course. On the other hand, just 32% of the boys said that they had been encouraged by a family member to take the course.

Another study indicated that the advice by parents –along with teachers and peers– to pursue CS career was a critical factor in influencing girls' choices (Meszaros, Creamer, & Lee, 2009; Zarrett, Malanchuk, Davis-Kean, & Eccles, 2006). A survey of 954 U.S. high school and college women also found that girls were significantly more likely than boys to seek direction and encouragement about careers. The same study indicated that encouragement provided by parents was more influential than that of counselors or teachers (Meszaros et al., 2009).

A study in Greece, concerning middle school students, indicated that parental support were associated with boys' sense of CS self-efficacy, while teachers expectations were more important for girls' sense of self-efficacy (Vekiri, 2010). Girls in that study - and other studies- had less home experiences with Computing and report less encouragement from parents (Barker & Aspray, 2006; Vekiri & Chronaki, 2008).

Denner (2011) in her study found that perceived parental support had a powerful impact on girls' interest in CS. A relative qualitative study showed that girls consider the encouragement and the support they get from family and parents as most influential factor for their decision to pursue Computing (Denner, 2009).

Another study concerning undergraduate students indicated that encouragement and support was a critical factor for girls to complete their CS studies and choose a CS career. Interestingly, this factor was more important than their confidence in CS and their perceived ability in the field (Guzdial, Ericson, McKlin, & Engelman, 2012).

Tsagala and Kordaki (2008) also studied critical factors influencing CS undergraduates and argue that students' families acknowledge their children's career opportunities through acquiring a CS degree, CS being a prestigious profession, and also acknowledge that entering a CS dept is a measure of their children's personal success. These students' family views are reflected as main motives for both their sons and daughters to select CS as a subject of study. They also note that, all students who expressed an interest/non interest in CS had had/not had previous informal -not school based- experience with computers, encouragement/discouragement by their school teachers and supporting/not supporting family views to their choice to study CS.

2.3.2.2 Early Exposure to Computers. There are also studies emphasizing on the role of the *early exposure* to computers and Computing, pointing out that a crucial factor is the kind of that Computing experience. Several studies have found that early usage of computers seems to improve success in future Computing classes (Barker & Aspray, 2006). Early exposure to Computing seems to favor boys, as research found that more boys than girls used computers at home, boys began using computers earlier, and boys used their computers at home on average more hours per day than girls (Barker & Aspray, 2006).

Abbate (2010) argues that one of the primary reason for females' under-representation in CS is their lack of experience. She maintains that as college students flocked to CS in the mid-1980s, depts tried to reduce the numbers to a manageable size by instituting entry requirements that favored candidates with prior computer experience, discouraging those students who had less experience or confidence. As a result, fewer women than men have been admitted to CS. The gendered effects of these changes were probably unintentional, but true.

Here, it is worth to note that, the majority of studies, presented in the literature review of Gürer and Camp (2002), have shown that boys and girls who spend more time with computers have a more positive view towards CS. So it is important to give both boys and girls equal exposure to computers in order to have positive experiences to carry through to their later years.

A study interviewing undergraduate students about their prior computer usage found that significantly more males reported early exposure to computers at home. On the other hand, significantly more females reported later exposure to computers (Varma, 2009).

Concerning the kind of Computing experience, Kent and Facer (2004) highlight that boys were more likely to use computers at home for fun and for Internet activities, whereas girls were more likely than boys to use the computer at home for writing.

A study of students in Greece indicated that opportunities for early familiarization with Computing in home is a key factor differentiating boys' and girls' motivation for studying CS (Papastergiou, 2008).

Even if computer use and early exposure in Computing is a key factor influencing children's choices and perception about CS, the *'creative production'* of technology in home seems to be another important factor. Barron (2004) studied males' and females' experience with that aspect – '*creating with technology rather than just use'*. Barron (2004) found that experiences with creative production was a significant factor in later success in CS courses. More boys than girls had that kind of experience. Interestingly, in most cases – apart from programming courses - girls and boys in the same 'experience level' had no differences in the confidence, interest or motivation. According to that study, girls with high levels of experience reported higher levels of confidence. Interestingly, boys reported as being confident regardless of their computer experience. Considering interest, more experienced females expressed a stronger interest to learn more, compared to less experienced females. Boys wanted to learn more independently with prior experience. Computer experience seems to be a significant factor affecting girls' and boys' decisions to major in CS or pursue a career in specific computer fields, e.g. programming, networking, etc. (Barron, 2004).

What is more, the community in which girls grow up has a significant impact on early exposure to the kind of Computing activities available (e.g., in extracurricular and community based programs), their exposure to other girls who participate in these activities, their exposure to adults who work in these professions and other role models, and the resources at home and school for engaging in these activities (Barker & Aspray, 2006). Even if the digital divide has narrowed, access is still a problem in some communities. This persistent divide can be a significant factor shaping boys' and girls' Computing experiences (Barker & Aspray, 2006; Margolis, 2010). Students introduced early in Computing come from families '*able to provide computers, internet access, robotic kits, a plethora of software*, *and parental knowledge (...) Many others*, *who lack high-quality schooling opportunities and substantial family resources, are relegated to the shallow end of Computing skills*' (Margolis et al., 2011, p. 68).

Even so, studies suggest that it is not only important how computers are presented to girls, but also when they are presented (Ashcraft et al., 2012; Gürer & Camp, 2002). Camp (1997) asserts that access to computers and training in the concepts of CS should be provided at preschool levels in order to give women the greatest chance to avoid developing insecurities about their abilities. A survey conducted by Google[12] in the summer of 2010 confirms the importance of introducing computers early in life, finding that 98% of CS majors were exposed to CS before college, while only 48% of non-majors could say the same.

To sum up, families can play a significant role in girls' and boys' decision about pursuing CS. The parental - or familiar - expertise or career in CS can play a role, but the parental support and encouragement have a decidedly powerful impact on girls' choices to persist. Early exposure to computers and Computing at home plays a role, but the kind of Computing experience seems to be the key factor.

2.3.3 Computer Games

Computer games can play a determine role in children's future interest in CS, as it is in most cases the first Computing experience of boys and girls. Research has shown that boys' interest in gaming is a possible reason for pursuing CS. In her survey, Carter (2006), found that the top reason boys would choose a CS major was interest in computer games. Girls on the other hand reported that they would choose a CS major because of their desire to use CS in other fields, whereas interest in computer games was, for them, the third most positive influence.

[12] http://blog.csta.acm.org/2011/03/30/no-more-excuses-for-lack-of-access/

Unfortunately, the majority of computer games target the boy market. Stereotypical representations and narratives are present in many computer games (E. Hayes, 2008). Moreover, many games created for girls reinforce stereotypes about the kinds of things girls are interested in (E. Hayes, 2005). The boy-dominated characteristics –shooting, violent graphics, loud noises– do not appeal to girls who tend to prefer games that encourage collaboration with other players and involve storylines and character development where female characters (Gürer & Camp, 2002).

Some studies, also, suggest that the games addressed to boys usually allow users to make programmatic modifications, which directly develop actual CS or programming skills (E. Hayes, 2008; E. Hayes & Games, 2008; Kafai, 2008). What is more, this feature tend to encourage online communities where boys interact, exchange knowledge with other players and gain more advanced skill (E. Hayes, 2008). However, research indicates that intervention programs using games to increase girls' interest in CS can have positive effects (Denner, Werner, & Ortiz, 2012).

While in the past boys spent more time gaming, some findings suggest that the gap is narrowing (E. Hayes, 2008). As girls have begun to start gaming in equal number to boys, evidence does suggest that gaming can be an engaging way to introduce CS for girls (Denner, 2011; E. Hayes, 2008). Taking this into account, games can be a promising way of making Computing classes more relevant for boys and girls and integrating them early in actual CS activities (E. Hayes, 2008).

Understanding fully the gaming practices of girls and how they learn CS concepts through these practices can held the better design of that programs (Denner, 2011).

To sum up, computer games, which are often children's first introduction to Computing activities, seemed to deter girls from computers, due to the fact, that these are designed mainly for male audiences with stereotypical representation. What is more, the opportunity for programmatic modification and other kinds of computational interactions may foster mainly boys', not girls, interest in CS. Nevertheless, the rise of gaming, the narrowing of the divide between boys and girls and its influence on girls' participation in Computing is worth of further research.

2.3.4 Role Models

Research in CS education finds that role models are important factors influencing girls' decisions to pursue CS (Barker & Aspray, 2006; Cozza, 2011; Gürer & Camp, 2001, 2002; Townsend, 2002). Women role models demonstrate the presence, the participation, and the continuing prospects of women in the field. When young women think about CS as a career choice, the presence of successful women in Computing is an encouraging signal (Gürer & Camp, 2001). One of the most important characteristics of a woman-role model is that girls perceive these role models as 'relatable' and similar to themselves. This perceived similarity to people in the field and a feeling that one will 'fit in' is a crucial factor in pursuing a CS career (Cheryan & Plaut, 2010; Cheryan, Siy, Vichayapai, Drury, & Kim, 2011).

Girls and young women need women role models in CS related professions who can inspire interest in CS careers and who can demonstrate to them that computer scientists have whole and satisfying lives inside and outside the workplace (Brunner, Bennett, & Honey, 1998).

There can be many types of role models, family members, teachers, faculty members and colleagues. Girls can interact with women computer scientists online or in person or learn about their stories through biographies and talks. Townsend (1996) argues that female attitudes towards CS significantly improved just watching a brief video of female role models. Stout, Dasgupta, Hunsinger, and McManus (2011) also examined the effects of female role models among STEM students and concludes that exposure to female role models can not only prevent girls from developing negative attitudes toward the sciences, but also reverse negative perceptions that have already formed. This study showed that female teachers will increase a woman's self-efficacy over time.

Female faculty in Computing depts provides the most appropriate form of mentoring for female students (Carrington, Tymms, & Merrell, 2008). It would appear to make sense that a certain level of comfort may be achieved between a female student and an accomplished female professor; both the mentor and the mentee are free to 'let their guard down' and speak freely of their concerns, aspirations, and fears (Gürer & Camp, 2001). The absence of female faculty in CS dept may deter young women from retaining in the field. When Cohoon (2001) examined dept characteristics that affect retention of female observed that, depts with no female faculty lost female students at high rates relative to men. One of the success factors of Harvey Mudd College -that experienced a success in attracting female undergraduates- was, that female freshmen are invited to a CS conference so they see the number of available role models from the beginning of their college experience (Alvarado, Dodds, & Libeskind-Hadas, 2012).

Girls are also affected by the presence of female colleagues who retain in the CS field and succeed. Cohoon (2001) observed that CS depts with a higher number of female students are more likely to retain them.

But several studies argue that even if girls need to see women like themselves in the persisting and be successful in the Computing field, they can not only relate to other girls and women (Cheryan & Plaut, 2010; Cheryan, Siy, et al., 2011). A combination of diverse male and female role models can have better results. Many girls and young women describe also the importance of male role models (Liston et al., 2007).

Summing up, the existence of females in the field - teachers, faculty, and colleagues – can inspire women, improve their self-efficacy, and reverse negative stereotypes as they can realize, through real life examples, that they can pursue, persist and succeed in CS. The perceived similarity, even across gender lines, and the feeling they 'fit in' is a crucial factor in pursuing CS.

2.3.5 Peers and Work Culture

Peers at school and at work can affect girls and women. Peers can have a powerful influence on children's beliefs and behavioral choices (Barker & Aspray, 2006).

Peer influence is really strong during school years, as students need to ensure acceptance of peers (Barker & Aspray, 2006). Girls' intention to pursue CS can be *positively affected* by the perceived support of peers. Denner (2011), studying middle school girls, found that perceived support from school peers had a direct effect on girls' interest in Computing classes and CS careers. Cozza (2011) also noted that, boys and girls consider peers as guides, especially when they lack adult mentors or role models. As a result, peer support and peer role models can have a very positive effect on girls' interest in CS (Cozza, 2011). Real-life examples of girls of the same age interested in Computing can have a positive effect on girls' plans to pursue CS.

However, peer influence can have a *negative effect* on girls' perceptions and interests if their peers are not interested in CS. Jenson, De Castell, and Bryson (2003), interviewing students, found that girls' interest in Computing classes was affected by the perception of the climate of these classes and the possible dominance of boys in the labs. In addition, girls in all –or mostly- boys' environments may feel uncomfortable being the only girl in the class.

Research has also shown that, often, *single-sex education* can benefit girls since that increases their confidence and interest in traditionally male-dominated fields (Barker & Aspray, 2006). Crombie, Abarbanel, and Trinneer (2002) studying all-female CS courses in secondary school, found that these environments can positively affect girls as they perceive more support from teachers. Girls regain their confidence, being more vocal than in other classes and they report more interest in Computing or potential to pursue a CS career. Gürer and Camp (2002) go further to argue that 'all-female environments' are better as they set classroom discourses free from male domination, diminishing gender-related perceptions and tensions.

As far as the workplace environment, peers influence seems to be crucial for women's decision to stay in Computing. In a study of STEM professionals in the private sector, Hewlett et al. (2008) found, that, many women appear to encounter a series of challenges at midcareer that contribute to their leaving careers in STEM industries concerning their relations with their peers and bosses. Women cited feelings of isolation, an unsupportive work environment, extreme work schedules, and unclear rules about advancement and success as major factors in their decision to leave.

Sexist humor and macho work culture is also identified as one key factor for women to leave Computing (Cohoon, Wu, & Chao, 2009). In addition, in the computer-game industry work conditions remain overtly hostile to female employees (Jenkins & Cassell, 2008).

Misa (2010a) also noted that there has been a gender-specific tail-off in the Computing workforce, where women leave the workforce in the middle of their career. That mid-career exit was not a result of women's choices, because they actually chose that profession, but women were pushed by *'macho work environments, serious isolation, and extreme job pressures'* (Misa, 2010a, p. 6).

However, Abbate (2010) interviewed successful women in Computing and provide clues describing CS not merely as a field where women can just survive, but one that is especially good for women. A field where *'stereotypes lose their sting'*, where work is both challenging and social. A focus on just negatives, such as discrimination, hostile climates in classrooms and workplaces, deters many women from considering a career in the field.

To conclude, peers, at school and at work, influence females' decisions and choices. Peer influences can have a positive effect on girls' plans to pursue CS or women's decision to persist. The flip side is, that peers can negatively affect girls' choices and women's decision if their peers are not interested in CS or supportive. A possible solution to that may be single-sex environments that can boost the positive aspects and mitigate some of the negative aspects of peer influences.

2.3.6 Stereotypes

Most recent studies argue that one novel and powerful social factor that may perpetuate the under-representation of women and girls in CS is the stereotypes about the culture of the fields (Cheryan et al., 2015; Cheryan, Plaut, Davies, & Steele, 2009). Cheryan et al. (2015) argue that stereotypes about CS act as '*educational gatekeepers'*, preventing females from joining Computing field. They support that students espouse several *stereotypes about the culture* of CS while *girls face negative stereotypes* about their *abilities*. Both sets of stereotypes may be operating simultaneously to make girls feel like they do not belong in CS.

2.3.6.1 About the culture of the field. Research has found that stereotypes about *computer scientists* lower high-school girls' interest in CS (Master, Cheryan, & Meltzoff, 2014). When students think of computer scientists, they often think of 'geeky' guys who are socially awkward and infatuated with technology (Mercier, Barron, & O'connor, 2006). The work in CS is seen as isolating and relatively dissociated from communal goals such as helping society and working with others (Diekman, Brown, Johnston, & Clark, 2010). Computer scientists and engineers are also perceived as having masculine interests (e.g., playing video games) (Cheryan, Siy, et al., 2011), and their faculty are more likely than faculty in other fields (e.g., biology, psychology) to believe that an inborn brilliance or genius is required to be successful (Leslie, Cimpian, Meyer, & Freeland, 2015).

Cheryan, Plaut, Handron, and Hudson (2013) reviewed the literature describing prominent stereotypes about computer scientists among students and present the computer scientist as someone who is *highly intelligent, singularly obsessed with computers*, and *socially unskilled* – an image that is pervasive in popular culture and in the minds of students.

Specifically, computer scientists are stereotyped as males *technology-oriented* with strong interests in programming and electronics (Cheryan, Meltzoff, & Kim, 2011), and little interest in people (Diekman et al., 2010). For instance, undergraduates stereotype computer scientists are viewed as highly-skilled computer programmers who enjoy tinkering with electronics (Margolis & Fisher, 2003). Both males and females undergraduates perceive that CS is isolating and does not involve communal goals such as helping or working with others (Diekman et al., 2010). This is also documented in the U.K. (Schott & Selwyn, 2000) and Australia (Lang, 2007). The perception that CS is technology-oriented rather than people-oriented may cause women to express less interest than men in the field (Diekman et al., 2010).

A second stereotype is that computer scientists are so *obsessed with technology* that they are *singularly focused on computers and programming*, to the exclusion of other interests (Beyer, Chavez, & Rynes, 2002; Margolis & Fisher, 2003). Computer scientists are stereotyped, by both male and female undergraduates, as having an '*obsession with machines*' (Beyer et al. 2003, p. 52) and being '*myopically focused ... to the neglect of all else*' (Margolis & Fisher 2003, p. 65). Similarly, high school students perceive computer scientists as '*fanatical*' with an '*addiction*' to technology (Schott & Selwyn, 2000). The stereotype that computer scientists are singularly focused on computers and programming may deter women to a greater extent than it does men.

Another stereotype of computer scientists is that they *lack interpersonal skills and are socially awkward* (Beyer et al., 2002; Mercier et al., 2006; Schott & Selwyn, 2000). Undergraduate students (Beyer et al., 2002; Margolis & Fisher, 2003), high school students (Schott & Selwyn, 2000), even middle school students are aware of this stereotype (Mercier et al., 2006). Stereotypes that computer scientists lack interpersonal skills can be contrasted with expectations that women are socially competent and people-oriented (Diekman et al., 2010).

Female and male college students perceive that the majority of computer scientists are *male* (Beyer et al., 2002; Cheryan & Plaut, 2010; Schott & Selwyn, 2000). Similarly, when elementary school children are asked to draw a scientist or a computer user, they overwhelmingly depict male scientists and computer users (Mercier et al., 2006).

Furthermore, computer scientists are also stereotyped by undergraduates as having *masculine interests* such as liking science fiction and playing video games (Cheryan, Meltzoff, et al., 2011; Cheryan et al., 2009). The stereotype that computer scientists are males who have masculine interests may lead some women to question whether they belong in CS.

Another stereotype about the culture of CS include a perception that it requires '*brilliance'* (Leslie et al., 2015). Computer scientists, are stereotyped as '*intelligent*', '*geniuses'* and '*logical'* (Beyer et al., 2002). The pervasive stereotype of computer scientists as being nerds or geeks further conveys the notion that they are smart (Beyer et al., 2002; Schott & Selwyn, 2000).

The pervasive image of the solitary male programmer, so wrapped up with Computing as to be 'dreaming in code,' is not universally attractive or inviting. Actually, in 1950s, people in the field (especially male programmers) intended to create a masculine Computing world of their own. A world where they would regard themselves as members of a priesthood too complex for ordinary people. To date, this Computing world is considered as the priesthood of 'nerds' (Misa, 2010a). Several different terms—grind, gnurd, hacker, tool, dweeb—have over the years described someone with an overwhelming attraction to the inanimate technical world.

The connection between CS and 'nerdiness' is endorsed by male and female undergraduates (Margolis & Fisher, 2003) and by high school students (Schott & Selwyn, 2000). When students think of a computer scientist, they tend to imagine a male who is '*unattractive', 'pale', 'thin', 'wearing glasses'* (Mercier et al., 2006). For example, drawings of computer experts by middle school students have included glasses, pale skin, and abnormal body weight. Males in sixth grade used a greater number of stereotypical characteristics in their portrayal of the computer experts, while males and females in eight grader used the same number of stereotypical characteristics in their drawings (Mercier et al., 2006). Stereotypes of computer scientists' physical appearance may deter women more than men (Margolis & Fisher, 2003).

C. C. Hayes (2010a) convincingly argues that these unappealing stereotypes of computer scientists as 'computer nerds' and 'hackers' has become known to the public and established in the general consciousness too early, during the 1970s and 1980s, since the discipline of CS became established and known. In that sense, the increasing prevalence of these stereotypes from the 1980s through the present day may have contributed to a decline in the proportion of women choosing CS. It seems that these stereotypes were probably unappealing to both men and women but disproportionally so to women. Patitsas, Craig, and Easterbrook (2014) agree with that and add that more women were present in CS when the 'boys' culture' was not dominant.

Computing stereotypes are pervasive in society and even young students endorse them. When high-school students described computer scientists, the majority (84%) mentioned at least one measurable stereotype, including being technically oriented, singularly focused on technology, socially awkward, masculine, intelligent, or having particular physical traits such as glasses or pale skin (Master et al., 2014). College students reported similar stereotypes, with 67% mentioning at least one of these stereotypes about computer scientists (Cheryan et al., 2013). College students were also less likely to believe that CS and engineering were fields that could be used to help people or work with others than fields such as medicine and law (Diekman et al., 2010).

In today's society, CS and engineering stereotypes are perceived as incompatible with qualities that are valued in women, such as being feminine, people-oriented, and modest about one's abilities (Cheryan, 2012; Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Leslie et al., 2015). As a result, when these stereotypes are prominent, females fell less belonging in the field (Cheryan et al., 2009; Master et al., 2014). The less that students feel a sense of belonging in a field, the less likely they are to pursue that field (Master et al., 2014).

All in all, the image of a computer scientist is one of a genius male computer hacker who spends a great deal of time alone on the computer, has an inadequate social life, and enjoys hobbies involving science fiction. These stereotypes are dominant in our society, students espouses them perpetuating them. These stereotypes deter those children, girls even boys, who feel out of that culture from pursuing CS studies or careers.

2.3.6.2 About girls' cognitive abilities. Stereotypes about girls' math abilities 'girls are not good at math' are negative (Cheryan et al., 2015). This stereotype may affect female students' self-confidence deterring them from pursuing a career in science.

However, difference in average math performance between girls and boys no longer exists in the general school population (Hyde et al., 2008). Actually, girls and boys tend to have different cognitive strengths and weaknesses (Hill et al., 2010). Generally, boys perform better on tasks using spatial orientation and visualization and on certain quantitative tasks that rely on those skills. Girls outperform boys on tests relying on verbal skills, especially writing, as well as some tests involving memory and perceptual speed (Hill et al., 2010).

One of the largest gender differences in *cognitive abilities* is found in the area of spatial skills, with boys and men consistently outperforming girls and women (Hill et al., 2010). Many people consider spatial skills to be important for success in science fields like engineering, although the connection between spatial abilities and success in CS careers is not definitive (Ceci, Williams, & Barnett, 2009). Whether or not well-developed spatial skills are necessary for success in science and engineering, research shows that individuals' spatial skills consistently improve dramatically in a short time with a simple training course (Hill et al., 2010). Sorby and Baartmans (2000) designed and implemented a successful course to improve the spatial-visualization skills of first-year engineering students who had poorly developed spatial skills. More than 75% of female engineering students who took the course remained in the school of engineering, compared with about one-half of the female students who did not take the course.

Ceci et al. (2009) reviewed more than 400 articles exploring the causes of women's under-representation in STEM fields (including Computing), referring to biological - as well as to social - factors, and concluded that the research on sex differences in brain structure and hormones is inconclusive. Female and male brains are indeed physically distinct, but how these differences translate into specific cognitive strengths and weaknesses remains unclear. Ceci et al. (2009) suggest that males and females use different parts of their brains to complete the same tasks. They conclude that '*men and women achieve the same general cognitive capability using somewhat different brain architectures'* (Ceci et al., 2009, p. 236). Overall, studies of brain structure and function, hormonal modulation, human cognitive development, and human evolution have not found any significant biological difference in men's and women's ability to perform in science and mathematics (Ceci & Williams, 2007)

The absence of negative stereotype about girls' abilities and the thought they can make it can boost girls' confidence and increase their interest in science fields. Hill et al. (2010) argue that when teachers and parents tell girls that their intelligence can expand with experience and learning, girls do better on math tests and are more likely to say they want to continue to study math in the future. Believing in the potential for intellectual growth, improves outcomes. This is true for all students, but it is particularly helpful for girls in mathematics, where negative stereotypes persist about their abilities. By creating a 'growth mindset' environment, teachers and parents can encourage girls' achievement and interest in math and science.

It has been shown that negative stereotypes about girls' abilities in math can indeed measurably lower girls' test performance. Researchers also believe that stereotypes can lower girls' aspirations for science and CS careers over time. When test administrators tell students that girls and boys are equally capable in math, however, the difference in performance essentially disappears, illustrating that changes in the learning environment can improve girls' achievements (Hill et al., 2010).

Summing up, even if there is not clear evidence that one of the two sexes is smarter than the other, the belief that girls' cognitive abilities lag behind boys' prevails. That stereotype affect girls' performance and self-efficacy deterring them from choosing science and Computing. What is supposed to be a 'free' choice is unconsciously guided by that stereotype as well. In the absence of that stereotype girl gain on confidence and perform equally well as boys.

2.3.7 Communication of stereotypes

The stereotypes about the culture in the field are communicated, perpetuated, and transformed through *media*, *people* in the field, and *school environment*. These stereotypes could be changed by trying to diversify the images of Computing.

2.3.7.1 Media. Media (popular movies and television shows, newspaper and magazines) portray computer scientists as mostly males, singularly obsessed with computers, and socially unskilled, often presenting only a small percentage of jobs in Computing (Cheryan et al., 2015).

Several studies have investigated the way in which CS and technology are portrayed in a variety of media texts (Misa, 2010a; Munson, Moskal, Harriger, Lauriski-Karriker, & Heersink, 2011; Sanders, 2005) and found prevalent gender stereotypes about people in CS and technical roles.

Tympas, Konsta, Lekkas, and Karas (2010) examined the construction of gender and Computing through advertising images. They examined 1500 Computing advertisements in the Greek home Computing journal '*Computer for all*' and they pointed out that in these advertisements, there is no shortage of women; but there is a very strong pattern in how women are shown with computers and what they are shown doing with them. In this study, it was shown that women are included in Computing advertisement through a specific gender-stereotyped manner. There is a dramatic representation of women working at the *keyboard-input* and the *printer-output* parts of computers. They are working on the screens, hands on the keyboard, dealing with the printer – fully engaged with the routine office working of Computing. On the other hand, men are rarely shown with hands on the keyboard and while they might receive a computer printout, they don't do the actual work of printing. Men are not working with the computer; they are in control of Computing work. It is the females who do the Computing work. This strongly gender-specific pattern was not followed when an engineer or a manager was shown. In this case the image on the computer screen was changed from a female eye or face (or the lines of typed-in figures or text) to a financial or engineering chart. Similarly, the pattern of showing the women sitting and keyboarding and the men standing and dictating was broken only when the sitting male was a student of a standing female teacher. In this case women were depicted as providing education to boys and only rarely to adult men. Concerning computer education, vocational computer schools advertised in the home journal, aimed at teaching students to be proficient at routine data-entry jobs, choose to show women doing this work, hands on keyboards, often with generic computers. But when they teach computer programming they typically show men at the job, often with an interesting variety of computers. Tympas et al. (2010) also argue that this advertising arrangement places women closer to the standardized, routinized, digital side of Computing, the side that is already analyzed and awaits passive computation. Men are placed at what has always been the expensive side, that of the analog Computing that is required to actively produce the Computing analysis. This follows a historically deep pattern of imaging men as ‘analysts’ and women as ‘computors’. Advertising, and other media have played a large role in establishing, spreading, and perpetuating images of men as the decision makers, experts, and innovators in CS, and women as ‘computer phobes’ or users who merely execute the instructions of men (Tympas et al., 2010).

The images of Computing, found in popular culture and mass media can shape practices, not always in straightforward ways. Corneliussen (2010), explored the cultural perceptions of computers in Norway, with a discourse analysis, studying the relationship between gender and computers in Norway’s largest newspaper. He noticed that newspaper reports were most likely to stress men’s mastery and competence in using computers while, in contrast, reports about women and CS often focused on their supposed indifference and lack of mastery or skill. These reports simply overlooked the large majority of male computer users who were not technical adepts as well as the sizable number of women who were technically proficient users of computers.

Media still portrays gender stereotypes and women are represented as holding little power or understanding of technology and being passive individuals (Cozza, 2011). Additionally, media images often still present the stereotype of computer professionals as geeks without social skills doing boring and solitary jobs (Ashcraft et al., 2012).

The power of media to alter the perceptions concerning gender stereotypes in CS can be confirmed by the progress that have been made in portrayals of other - once male-dominated - fields. Ashcraft et al. (2012) note *‘in many television shows, women are now portrayed in powerful positions in previously male-dominated areas’* and they highlight *'the power of popular culture to raise awareness and influence youth perceptions about occupations*' (p.28). Once established, the stereotypes became self-fulfilling prophecies by rendering invisible the people who did not fit the stereotype, such as female computer users and the large number of computer- phobic males.

While stereotypes can be remarkably persistent, they can and do change over time. Corneliussen (2010) showed how the media's discourse on Computing changed over time from '*computers for all*' in the early 1980s, to '*men are computer geniuses*' while '*women are computer-phobes*' in the 1990s to '*women have invaded the internet*' and '*male computer nerds can have a tan too*' in the 21st century.

Cheryan et al. (2013) examined to what extent the exposure to media representations - stereotypical and non-stereotypical- influence women's interest in CS. In their experiment, female undergraduates read a short newspaper article about computer scientists. There were two versions of the article: one that supports that CS is dominated by 'geeks' and one that assures that CS is no longer dominated by 'geeks'. What the authors found is that women were less interested in majoring in CS after reading the stereotypical article. Furthermore, women who read the non-stereotypical article were significantly more interested in CS than women who read no article.

2.3.7.2 People in the field. People in Computing field (CS professionals, as well as school teachers and students) embody certain characteristics, habits, and belief systems that can signal what is normative and valued in the field.

Cheryan, Siy, et al. (2011) experimented how people embodying CS stereotypes can influence women's interest to CS. For that reason female undergraduates were involved in a 'getting to know each other' task. The task involved having a conversation with a person (actor) who stated that he/she was a junior and a CS major. There were male and female actors. The conversation was brief and consisted of the participant and the actor exchanging basic information about themselves (e.g., year, major, hobbies, and favorite movie). Half of the participants were randomly assigned to interact with an actor who fit current stereotypes in appearance and preferences (e.g., glasses, t-shirt that said 'I code therefore I am,' hobbies that included playing videogames) or one who did not fit these stereotypes (e.g., solid colored t-shirt, hobbies that included hanging out with friends). After the conversation was complete, participants were asked about their interest in CS major and then asked the same questions again two weeks later. Results showed that women who interacted with the stereotypical student were significantly less interested in majoring in CS than those who interacted with the non-stereotypical student, and this effect was equally strong regardless of whether the actor was male or female. Moreover, negative effects of stereotypes endured for 2 weeks after the interaction (Cheryan et al., 2012).

The gender of the CS major mattered less in influencing women's interest in CS than the extent to which he or she fit current CS stereotypes. Women felt less similar to the stereotypical student than to the non-stereotypical student, suggesting students may look to other characteristics besides gender when determining with whom they feel similar (Cheryan, Siy, et al., 2011). When the people in CS depict themselves in a manner consistent with the stereotypes, it can convey to other students that one must fit the stereotypes to be successful in these fields. Moreover, fewer female students are present in fields whose faculty believes that success in their field requires innate brilliance, a belief that is prominent in CS and engineering (Leslie et al., 2015).

2.3.7.3 School Environment. School environment (e.g. computing classrooms), that fit CS stereotypes and are compatible with characteristics, interests, and values associated with males are likely to deter females from CS (Cheryan et al., 2015)

Cheryan et al. (2009) studied how objects in a Computing class can influence undergraduates' interests to CS. In their experiments, both male and female undergraduates who were not CS majors were invited to a room in the CS dept at Stanford University either filled with stereotypical objects of a computer scientist (Star Trek poster, comics, videogame boxes, soda cans, electronics, software, computer parts and technical books and magazines) or non-stereotypical objects (nature poster, neutral books, water bottles, healthy snacks, general interests books and magazines). Women in the room that did not contain the stereotypical objects expressed significantly more interest in majoring in CS than those in the room that did fit the stereotypes. For men, the environment did not affect their interest in CS (Cheryan et al., 2009). Similar results came up when undergraduates were asked to join an online educational environment. Students entered two virtual Computing classrooms (in Second life); one contained stereotypical objects while the other contained non-stereotypical ones. The stereotypical classroom was chosen by 60% of males and just 18% of females. Females expected to perform worse than males in the stereotypical classroom, but equally well in the non-stereotypical classroom (Cheryan, Meltzoff, et al., 2011). In both cases females reported a lower sense of *belonging* in the stereotypical environment. In contrast, men reported an equal, and sometimes greater, sense of belonging in the stereotypical environment than the non-stereotypical environment (Cheryan, Meltzoff, et al., 2011).

Studies with high-school students had similar results. Master, Cheryan, and Meltzoff (2016) studied the effects on students' interest in taking an introductory CS course in a stereotypical and a non-stereotypical classroom. In the absence of a description of the classroom, girls expected that it would fit the CS stereotypes and thus their interest was low. Their interest in taking a CS course in a stereotypical classroom was at the same, low, level. However, a CS classroom that did not project current CS stereotypes caused girls, but not boys, to express more interest in taking CS than a classroom that made these stereotypes salient. This non-stereotypical environment provided a new image of CS. It seems that high-school girls felt a lower sense of fit with current CS stereotypes than did boys.

2.3.7.4 Diversifying the Images of Computing. If the popular image of the Computing field is a significant factor in the gender gap, then diversifying the popular images may be a crucial strategy. While, it may be difficult to erase the already established stereotypes, multiple images and possibly contradicted stereotypes can coexist (Misa, 2010a). Fortunately, people can hold multiple, possibly conflicting images stereotypes of a single profession, simultaneously. For example, in the mid-1990s during the Internet craze, several Computing stereotypes coexisted simultaneously including the 'evil hacker,' the 'whiz-kid nerd', and the twenty-something entrepreneur-millionaire (C. C. Hayes, 2010b).

Actually, in some cases, stereotypes of computer scientists can be a source of pride, identification, and belonging for some in the field. Despite the fact that many students find them incompatible with how they see themselves, these stereotypes might not be so problematic. In all studies investigating effects of stereotypes, there is a sizable portion of students who may be drawn to these fields *because* of these stereotypes (Cheryan et al., 2015).

By diversifying the image of the Computing field, students who are interested will not think that they must fit a specific mold to be a successful in Computing. Diversifying the image of the field may not only attract more women in the field, but also make a more comfortable environment for men (Cheryan et al., 2015).

Actually, concerning the Computing environment, some men preferred the non-stereotypical environment over the stereotypical one (Cheryan et al., 2015). What is more, some men also highly value opportunities to work with and help others (Diekman et al., 2011). Attracting more men that do not fit to the 'computer scientist stereotype' is a way to stretch stereotypes and diversify the field.

Cheryan et al. (2015) state that females to date are exposed to an image of Computing that is not realistic and does no depict CS in full extend. This image presents Computing cultures as fitting a narrow profile. A broader image that shows many different types of people and working environments in CS represents a more realistic portrayal. Cheryan et al. (2015, p.6) believe that '*once we start the process of welcoming more women and girls (into Computing), the process of culture change will likely build on itself and contribute to further improving the actual and perceived culture of these fields for women*'. They believe that we have to encourage diversity of backgrounds and ideas.

There are two successful real-world examples of CS depts at -Carnegie Mellon and Harvey Mudd - that increased the proportion of women majoring in CS by changing stereotypes of CS in addition to structural changes. That change involved: use of diverse role models, exposure of students to a variety of CS applications and a reform of introductory CS courses so that Computing was not seen as a '*geeky, know-it-alls*' field (Cheryan et al., 2015).

Specifically, Margolis and Fisher (2003) performed a study in the mid-1990s when the Carnegie Mellon CS dept had a very gender-imbalanced environment. They interviewed approximately 100 students and found many differences between the male and female students in background, prior computer experience, computer programming skills, and feelings of satisfaction and inclusion in their program of study. In the late 1990s the dept made some changes to its admission standards with the goal of attracting more women. They kept high admission standards, but added an emphasis on leadership qualities and dropped requirements for prior programming experience. Additionally, they added a few ‘catch-up’ courses to the curriculum to level out background differences. None of these changes were inherently gender specific, but after implementing them the dept increased the percentage of women students from somewhat less than 10% to more than 30%, and greatly changed the culture. Frieze and Blum (2002) discovered, by interviewing students during and after these changes, that as the environment became more gender balanced, many of the apparent differences observed earlier by Margolis and Fisher began to fade. The background of both male and female students became more diverse, and the level of satisfaction of both had increased.

To *sum up*, the stereotypes about the culture of Computing –people in the field, work, and values– and the abilities of girls are communicated through media, people in the field, and Computing environment. Media and popular culture -persisting on a small percentage of Computing jobs- present Computing as masculine and geeky. The different images impact our ideas and our ideals, including whom we see as qualified for Computing work when we see certain kinds of people doing certain jobs. But media also have the power to alter the stereotypes if someone see the progress has be done in portrayals of other occupations. Moreover, people in the field with their characteristics, their habits, and their beliefs, as well as a Computing environment that reflects all the stereotypes can discourage women from CS. Diversifying the popular images of the Computing field seems to be a promising strategy. In that way we can attract women, as well as men, in the field who are interested and have not to believe that they must not adapt to a certain matrix to be successful. In addition to diversifying the field, men free of stereotypes in CS can favor a progressive mitigation of the negative stereotypes.

2.3.8 Girls’ Perceptions, Interest, Confidence, Attitude and Career Choices

Girls’ perceptions, interests, confidence, attitudes and career choices are shaped by the larger society and local environments in which they learn about Computing and technology, and this significantly influences what appears to be their *‘choices’* to pursue CS and CS careers. The aforementioned factors preclude women from being able to make a truly ‘free’ choice (Ceci et al., 2009). Girls do not come by these perceptions, interests, and career decisions innately or develop these beliefs and perceptions in a vacuum.

Recent research indicate that girls and boys perform in CS at comparable levels, when they realize similar training and experience, showing no innate reason boys would be better at technology (Voyles, Haller, & Fossum, 2007). In a study conducted in Greece, Ilias and Kordaki (2006) studied 1957 degrees earned by Computer Engineers and revealed that, in terms of achievement, there were no significant differences between male and female graduate computer engineers.

2.3.8.1 Perceptions of Computer Science. Girls, even boys, either have very limited knowledge or inaccurate perceptions about what CS careers involve and what CS professionals do. They perceive CS careers as having little or no interaction with others and that CS professionals are obsessed with computers (Anderson et al., 2008; Lasen, 2010; Papastergiou, 2008).

A study on high school students showed that 80% of students, both male and female, had no idea what CS undergraduate students learn (Carter, 2006). Students who believed they knew responded that it's about learning programming. According to the results of the study, just 2% of the high school students surveyed *'had a reasonably good grasp of what the field of CS entailed'* (p. 29).

In a study conducted in a summer camp for girls in US, when girls were asked about what a computer scientist can do in his/her free time, 72% believed that he/she would be at a computer; working or playing games. When asked about the appearance of a computer scientist, they tend to describe or draw a person with glasses and lab coat (Cannon, Panciera, & Papanikolopoulos, 2007).

The stereotypes about the culture of the field are still predominating in girls and boys. As discussed above, girls (and boys) perceive CS to be a field dominated by genius male computer hackers who spend a great deal of time alone on the computer, have an inadequate social life, and enjoy hobbies involving science fiction.

2.3.8.2 Interest in Computer Science. One of the basic motivators for girls' and boys' decisions to pursue CS studies is their interest in CS as a subject (Tsagala & Kordaki, 2007, 2008). Nevertheless, girls and boys are not equally interested; even interest varies among girls already interested in science.

A study from the Girl Scout Research Institute (GSRI[13]) explored what 852 girls say about their interests and perceptions concerning Computing and other STEM fields. That study found that girls were overwhelmingly interested in STEM as 74% of high school girls were interested in fields and subjects of STEM, and that the *creative* and *problem solving aspects* of STEM draw girls. Girls reported that, through their studies and occupations, they want to help people and *'make a difference in the world'.* Concerning Computing, when they were asked, *'How interested are you in CS/Information Technology (computer programming, networking, security, computer support, etc)'* 41% of all girls expressed interest, and 51% of girls who were already interested in STEM expressed interest. According to that report, compared to girls who were not interested in STEM fields (non-STEM girls), girls interested in STEM fields (STEM girls) were higher achievers, better students, had stronger support systems, and had been exposed early to STEM fields. Compared to non-STEM girls, STEM girls have higher confidence in their academic abilities and have higher academic goals and aspirations for themselves. Also, STEM girls have more career support from parents, family members, teachers, and friends, compared to non-STEM girls and have had greater exposure to STEM fields (know someone in STEM, experience in STEM activities). However, increased interest does not always imply an intention to persist. Interestingly, what that report indicated is that interest in STEM fields doesn't necessarily translate into choosing one of these fields for a career. Although interest in STEM is high, few girls consider it their number one career choice. Specifically, when girls asked if they were interested in a career in CS/Information Technology, 27% of STEM girls and 11% of non-STEM girls reported interest. A CS career seems not to be among the first choices of STEM and non-STEM girls. Surprisingly, *'Stay-at-home mom'* was a more popular choice even in STEM girls (30%). When asked for their first choice, just 1% of STEM girls and 0.8% of all girls answered CS.

As one of the contributing factors to the interest of girls in CS is the extent to which they see the value and relevance in the CS (Denner, 2011). Changing girls' limited knowledge and inaccurate perceptions is vital for increasing their interest. Interest in an

[13]https://www.girlscouts.org/content/dam/girlscouts-gsusa/forms-and-documents/about-girl-scouts/research/generation_stem_full_report.pdf

occupation is influenced by many factors, including a belief that one can succeed in that occupation (Hill et al., 2010).

2.3.8.3 Confidence. Gürer and Camp (2002) argue that self-confidence is influenced and formed by four different components: performance and accomplishments, observing and learning from others, freedom from anxiety concerning work and conduct in a particular field, as well as persuasion and support from others.

Boys have expressed higher levels of confidence with computers (Barker & Aspray, 2006). Contrarily, recent findings concerning the relationship between gender, confidence, and Computing reveals that girls express lower levels of confidence, rating their ability lower than boys, even when actual achievement levels are similar (Ashcraft et al., 2012).

In their study, (Moorman & Johnson, 2003), asked male and female students to rate their CS ability, comparing that to other students'. Just 19% of females claimed that they are better than their male classmates, and 37% claimed to be better than other females in their classes. On the other hand, 65% of male students claimed that they are better than their female classmates, and 52% claimed to be better than other males.

In an experimental study, 206 participants observed a target person (either a woman or a man) on a video solving a complex computer task successfully (Sieverding & Koch, 2009). Participants had to evaluate their own (hypothetical) computer competence in comparison to the target person. Findings showed that women judged their competence to be lower than did men, and both women and men judged their own hypothetical performance in the computer-related task to be relatively higher when comparing it to the identically scripted performance of a woman versus a man.

Experience seems to be a critical factor influencing girls' confidence in Computing (Cohoon & Aspray, 2006; Guzdial et al., 2012). The confidence in using computers increases as boys and girls gains experience with computers. Research argues that girls are entering introductory CS courses at universities with less experience than boys (Cohoon & Aspray, 2006). The prior knowledge that CS programs assume for their students, that girls may have not obtained, can be considered as lack of ability or interest, discouraging females (Gürer & Camp, 2002).

Programming experience ensures programming achievement, regardless the gender of the programmer. Students with equal levels of programming experience, perform at the same level (Bruckman et al., 2009). Despite that fact, girls often evaluate their own abilities lower than do boys with same levels of experience (Guzdial et al., 2012). Even female CS majors found that they had less confidence than did male non-majors (Beyer et al., 2002).

Research, also, has identified that lower levels of confidence and underestimation of competence can be triggered by the feeling that *'our actions will confirm negative stereotypes about our group or about ourselves as members of a group'* (Spencer, Steele, & Quinn, 1999). The so called 'stereotype threat' is a situational predicament in which people are or feel themselves to be at risk of confirming negative stereotypes about their social group. These feelings can negatively affect performance, confidence, and risk-taking behavior (Spencer et al., 1999). The lack of confidence, or reduced performance, may be attributed to the personal characteristics of girls if someone does not recognize that *'stereotype threat'*. Recognizing stereotype threat – teachers, parents and everyone else- can encourage girls overcome fear and anxiety about their actions, perform at their full potential and pursue CS.

Encouragement seems to be another important factor affecting self-confidence and perceived ability. A study of 1,434 undergraduate students indicated that encouragement to persist was the decisive factor for female students to choose a CS major or career (Guzdial et al., 2012). The importance of encouragement from parents, teachers, and other influencers is a very consistent finding across studies and is promising to design interventions aimed at increasing girls' and women's participation (Ashcraft et al., 2012).

After all, it seems that confidence in CS ability and encouragement from 'important others' are the two key factors influencing girls' choices and predicting their intentions to pursue CS (Zarrett et al., 2006).

2.3.8.4 Attitudes. Gürer and Camp (2002) argue that positive attitudes towards CS can greatly influence the success of a female-student and also whether she continues in CS. Students in elementary school seem to have positive attitudes toward Computing, it is later that gender differences in attitudes become pronounced. Nevertheless, the majority of studies, presented in the literature review of Gürer and Camp (2002), have shown that boys and girls who spend more time with computers have a more positive view.

One study using data of a Dutch large-scale survey on ICT use in primary education (4,000 grade 5 students), explored the influence of both *non-school related factors* (gender stereotyped views, encouragement by parents, computer use and self-efficacy) and *school related factors* (pedagogical approach, structural teacher characteristics) on students' computer attitude (Meelissen & Drent, 2008).

According to the aforementioned study more boys than girls have *gender stereotyped views* of computers. Despite the fact that, girls with less gender-stereotyped views on computers were expected to have more positive computer attitudes, that study showed that gender stereotyped views on computers were not related to girls' and boys' computer attitude. On the other hand, the intensity of *computer use and self-efficacy* beliefs in computer use have a positive effect on boys and girls computer attitude. Boys report considerably more frequent computer use outside school hours than girls do. Outside school hours, more boys than girls use email and the Internet, while more girls than boys use the computer for drawing and word-processing. The variety of computer use outside school hours has a positive effect on the computer attitude of boys but not on that of girls. Compared to girls, boys judge their *self-efficacy* in computer use more positively, especially with regard to the use of email and the Internet. Boys with more confidence in their abilities had more positive attitudes toward Computing.

It is also plausible that the influence of these factors on computer attitude is reciprocal. For example, the more positive the computer attitude of a student, the more interested he / she will be in using computers and trying (new) Computing applications, resulting in an even more positive attitude toward computers. Because girls show lower intensity and lower self-efficacy in computer use than boys, these reciprocal relations may increase gender differences in computer attitudes in the long term. Thus, gender differences in computer attitude may increase with age.

Despite the fact that, the computer use at home by parents seem not to affect the computer attitudes of children, the extent to which students experience encouragement by their parents to use and learn about computers turns out to be an important factor influencing their attitudes. It seems that the more encouragement from parents to use computers, the more positive their attitudes are toward computers. Gender differences in computer attitude seem to be related to gender differences in students' perceived encouragement by parents in Computing.

Concerning the school characteristics, the *pedagogical approach* followed in school has an effect on students' computer attitude. Regarding boys, the pedagogical approach has no particular influence on their computer attitude, unlike girls for whom a mainly student-oriented pedagogical approach appears to have less positive effect on their computer attitudes compared to a mainly teacher-centered pedagogical approach. On the other hand, according to that study, *structural teachers' characteristics* (gender, teaching practices and computer experience) were not related to students' computer attitude.

Sáinz and López-Sáez (2010) analyzed the existence of gender differences in computer attitudes in a sample of 550 Spanish secondary students. The results of their study verify their predictions about women's lower computer attitudes than their male counterparts. They argue that even though women hold fewer positive computer attitudes than men, it cannot be assumed that their attitudes towards computers are negative. The fact that boys and girls exhibit different computer attitudes could entail that they differ in their motivations and interests in considering the utility of computers, as well as the role computers play in their lives. Their findings prove that the fact that girls hold more positive attitudes about CS professional's social skills could reveal the communal orientation with which girls associate all occupations, in general, and the antisocial image society holds with regard to computer scientists. On the other hand, the fact that boys hold more positive attitudes about CS professional's intellectual aptitudes than their female counterparts could indicate that this aspect is a challenging and attractive justification for boys, because it is more prototypical of the instrumental-agentic trait traditionally associated with men.

A study involving 51 male and 46 female CS majors at Carnegie Mellon University provides evidence of a 'female' inclination to serve people and society (Margolis, Fisher, & Miller, 2000). Interviews from female CS students revealed female students' views to people-oriented purposes for computers. According to that study, 44%

of the female students (as compared to 9% of the male students) emphasized the importance of integrating Computing with people through projects with a more human appeal. Overall, women preferred CS for medical purposes, communication, and solving community problems over Computing for the sake of Computing, developing better computers, or programming for games.

A previous study by Fisher, Margolis, and Miller (1997) found that many women want to use computers as a way to make society better, while accordingly, a survey done by ACM/WGBH in 2009[14] shows that the majority of girls prefer descriptions of CS that appeal to their sense of community and ability to 'do good' in the world, whereas boys prefer descriptions which show CS as a tool to help them be in control of their own lives.

Finally, women's negative computer attitudes have been associated with their scarce representation in technology and CS studies (Anderson et al., 2008; Sáinz & López-Sáez, 2010).

All in all, it seems that girls' (positive) attitude towards Computing may affect their engagement in the field. However, several *non-school* and *school* related factors have an impact on these attitudes. It is obvious that students' self-efficacy beliefs, in fact more than gender stereotyped views about CS, influence their (positive) attitude towards CS, while (perceived) parental encouragement also plays a critical role in shaping their attitude. Eventually, the *pedagogical approach* followed in school seems to have an effect on girls' attitude towards CS, who place much more emphasis upon the social aspect of CS and its people-oriented dimension.

2.3.8.5 Career choices. Boys and girls pursue a CS major or career for several reasons. Sometimes they are different but in some cases there are similarities.

Carter (2006), studied 836 students in high schools, and found that the most important reason boys chose a CS major was interest in computer games. On the other hand, the most important reason girls chose a CS major was their desire to use Computing in another field. Interestingly, the most important reason, for both girls and boys, for not choosing a CS major was the lack of desire to sit in front of a computer all day.

[14] http://www.acm.org/press-room/news-releases/2009/nic-interim-report/

Another survey of 1,434 introductory CS students (Guzdial et al., 2012) found that the 3 top reasons for choosing a CS major are the same for both males and females. Both boys and girls said that the most important reasons were: *'I enjoy working with computers', 'Computing offers broad and diverse opportunities', 'Computing provides good financial opportunities after'.* Girls were significantly more likely than boys to say that they chose a CS major because of their *'interest in helping people or society'.* Boys were significantly more likely than girls to say that they chose computer major because of their '*interest in computer games*', *'interest in solving problems with Computing,' and 'liking to program computers'*. Concerning the reasons for choosing a CS career, both girls and boys placed a high value on *communal* career characteristics, like *'having the power to do good', 'doing work that makes a difference',* higher than having a *prestigious and secure* career or a *creative and innovative* career.

In a study conducted in Greece, 248 high school students, both males and females, were asked, through questionnaire, about the factors affecting their decisions whether or not to pursue undergraduate studies in CS (Tsagala & Kordaki, 2007). According to that study, basic motivators for males included an interest in CS as a subject, rich employment opportunities, financial gain and experience with computers. Basic motivating factors for females were also an interest in CS as a subject, job security and good living examples, such as charismatic teachers, successful family members in CS and mentors projected by the media.

According to the same study, the context of school seemed to provide motives for and against taking up CS as a profession, in terms of the teacher as a mentor (or not) and the school's infrastructure (adequate or not). School seemed to positively affect the decisions of more females than males in choosing studies in CS. This study also argues that friends can also affect students' choices. Friends seemed explicitly to affect, positively or negatively, males more than females. Based on the results of this study, more males than females imagine their future after studying CS to be in a profitable career in the Computing Industry, while a considerable percentage of females expressed an interest in a CS-based career to attain job security, mainly in the public sector.

A research conducted on a sample of 99 Greek CS university undergraduates, 43 of which were women, investigated students' views regarding several issues about gender differences in Computing. This study revealed that males are equally motivated to select CS as a subject of study in terms of their interest in this subject and because CS provides great career opportunities, while females are mainly attracted by CS - job security (Tsagala & Kordaki, 2008)

Wang, Hong, Ravitz, and Ivory (2015) conducted a study with 1,739 high school students to identify the critical exposures and experiences that influence a woman's decision to pursue a CS degree. According to their study, among the 91 factors with the potential to influence a decision to pursue a CS degree, the four most influential factors were: *social encouragement, self-perception, academic exposure, and career perception.* Specifically, that report, identifies as encouragement and exposure as leading factors influencing females' decisions to pursue CS studies.

Social encouragement includes positive reinforcement from family and peers and, according to that report, influence high school girls' decision to pursue CS. For high school girls, peer encouragement is almost as important as familial support. Encouragement from family, friends and educators, regardless of their technical expertise, reinforces existing interest and can foster interest where none exists. Encouragement from family as well as from non-family (teachers, role models, peers, media) contributed significantly more to girls' decisions to pursue a CS-related degree when compared to boys.

What is more, girl's interest in and perceptions of their own proficiency in mathematics and problem-solving significantly influence their decision to pursue a CS degree. This confidence may be reinforced by a preference in Mathematics or a natural aptitude for technology, but the '*ultimate source is a passion for, and interest in, related concepts like puzzles, problem solving and tinkering'* (Wang et al., 2015, p. 4).

Moreover, the exposure to CS courses and activities influences females' decisions to study CS (Google, 2014). Regardless of how females were exposed (high school curricula, extra-curricula programs - camps, clubs), young women who had opportunities to engage in CS coursework were more likely to consider a CS degree than those without those opportunities (Google, 2014).

Finally, the familiarity with and perception of CS as a career with diverse applications is another influential factor for girls' decisions to pursue CS (Wang et al., 2015). Not understanding CS as a discipline, and a flawed perception of the discipline dissuades young women from considering it. Young women unfamiliar with CS and its broad applications have difficulty visualizing it outside the narrow scope often presented in popular media (Google, 2014). In this way, young women may be unable to perceive CS as a career that meet both the academic quest (inventing, problem solving, exploration, etc.) and the social benefits (helping people, conservation, medical breakthroughs, etc.) that make a profession personally rewarding (Wang et al., 2015).

Recently, Webb and Miller (2015), surveyed 5,720 middle school students of both genders and found that, student perceptions about their own beliefs of their ability to use computers and solve problems with computers are likely to feed into their choices of future careers. Students' perceptions about how rewarding a career may be likely plays into emerging career interests, although perhaps in different ways for boys and girls.

To sum up, girls' perceptions of and interest in CS, confidence and perceived ability, attitudes towards CS and study and career choices are influenced and shaped by the larger environment they learn about Computing, especially by the factors described above. Girls' perceive CS as mainly masculine field, because of the limited knowledge or inaccurate perception they have about the field, mainly shaped by the images projected by the media, deter women from the field. Enriching and diversifying the images of Computing, can foster girls' interest in the field, as this interest can be shaped by the extent to which they see the value and relevance in CS. But girls' interest in Computing does not necessarily translate into interest in a career in CS. Interest in CS as a field of study or occupation is influenced by their belief that they can succeed in that. However, girls express less confidence and rate their abilities lower than boys even when actual achievement levels are equal. Experience can play an important role reinforcing their self-confidence, while encouragement can mitigate differences in levels of self-confidence and perceived ability. Moreover, positive attitudes toward Computing can greatly influence girls' pursue of a career in the field. Girls do not hold negative attitudes towards computers and Computing but a few girls express positive attitudes. These attitudes are shaped by the barriers discussed above and mainly, experience, self-efficacy, encouragement, stereotypes and preferences. Finally, career choices are shaped by the majority of factors discussed so far, but it seems that the key factors influencing females' decision to pursue CS studies or careers are the social encouragement, the self-perception, experiences with and exposure to Computing activities, and career perceptions.

Chapter 3.

Teachers’ Beliefs and Practices

Summary: This chapter provides a critical overview of the research in the field of teachers’ (gender-related) beliefs and practices. In particular, teachers’ educational beliefs are discussed and emphasis is placed upon their impact on the teachers’ decisions in the educational setting and their actual classroom practices. Due to the fact that, the research literature in Computing teachers’ gender-related beliefs and practices is limited relevant research literature, on gender-related teachers’ beliefs within Science, Technology, Engineering and Mathematics disciplines is resorted and presented, stressing their impact on teachers’ actual practices. Regarding Computing, teachers’ gender-related beliefs and practices, these are mainly pointed out in the context of information and communication technologies. Finally, methods for eliciting and assessing teachers’ gender-related beliefs and tools for investigating their actual practices in class are highlighted.

3.1 Beliefs

Beliefs and belief systems began to be examined at the beginning of the 20th century, mainly in social psychology (Throndsen & Turmo, 2012). New interest in beliefs emerged mainly in the 1970s, as the developments in cognitive science triggered educators' interest in studying teachers' beliefs and conceptions (Abelson, 1979).

Despite the fact that beliefs have been described as the most valuable psychological construct in teacher education, influencing the ways' people conceptualize task and learn from experience (Nespor, 1987), they have also been acknowledged as being notoriously difficult to define since "*as a global construct, belief does not lend itself to empirical investigations*" (Pajares, 1992, p. 308). Researchers have yet to come to a consensus on the meaning of what is a belief and no clear agreement about the definition has been reached. Thus, the concept has acquired a rather fuzzy usage (Borg, 2001). Researchers in the education field have provided several definition about term *'belief'* (see sections 3.1.1) and through their work, many of them, highlighted the distinction between *knowledge* and *belief* (see sections 3.1.2), focusing on the structural features of *beliefs* that serve to distinguish them from *knowledge* (see sections 3.1.3). Researchers' views about the structure of beliefs changed over time. Early approaches viewed beliefs as a uni-dimensional system, yet, due to the deficiency of this approach, researchers identified the concept of beliefs though a multi-dimensional system, which introduced the idea of *belief systems* (see sections 3.1.4).

3.1.1 Defining the Term

The term *belief* is so popular in the education literature that many who write about beliefs do so without defining the term. "*For the most part, researchers have assumed that readers know what beliefs are*" (Thompson, 1992, p. 192).

Pajares (1992) refers to beliefs as a "*messy construct*", one that has not always been clearly defined and "*travels in distinguish and often under alias*" (Pajares, 1992, p. 309). These aliases include "*implicit knowledge*" (Richards, 1998), "*implicit theories*" (Clark & Peterson, 1986), "*personal theories*" (Sendan & Roberts, 1998), "*explicit propositions*" (Nisbett & Ross, 1980), "*subjectively reasonable beliefs*" (Harootunian & Yarger, 1981), "*conceptions*" (Ekeblad & Bond, 1994), "*cognitions*" (Kagan, 1992), "*personal pedagogical systems*" (Borg, 2001), "*untested assumptions*" (Calderhead, 1996), "*perspectives*" (Tabachnick & Zeichner, 1986), "*theories for practice*" (Burns, 1996), "*images*" (Golombek, 1998) and "*maxims*" (Richards & Freeman, 1996).

The conceptual confusion has arisen as a result of defining identical terms in different ways and using different terms to describe similar concepts (Clandinin & Connelly, 1986). This difficulty in defining beliefs and the inconsistencies of the available definitions may be explained by the agendas of the researchers and studies (Pajares, 1992). Researchers from diverse fields may create new definitions which best fits their work, thus, educational research community has been unable to adopt a specific definition.

Pajares (1992) provided the available definitions of beliefs given by different researchers, noting that belief is defined as "*mental constructions of experience–often condensed and integrated into schemata or concepts*"; "*reasonably explicit 'propositions' about the characteristics of objects and object classes*"; "*something beyond itself by which its value is tested; it makes an assertion about some matter of fact or some principle or law*" (p. 312-313).

Rokeach (1968) defined beliefs as, *"any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase, 'I believe that….'"* (p. 113). He claimed that all beliefs have a cognitive component representing knowledge, an affective component capable of arousing emotion, and a behavioral component activated when action is required. This approach differentiates from other cognitive researchers' assumptions that belief is a type of knowledge, arguing that knowledge is a component of belief.

Borg (2001) drawing on the common features of the definitions given to beliefs concluded that *"a belief is a proposition which may be consciously or unconsciously held, is evaluative in that it is accepted as true by the individual, and is therefore imbued with emotive commitment; further, it serves as a guide to thought and behavior"* (p. 186). Actually, a belief is a mental state, which has as its content a proposition that is accepted as true by the individual holding it, although the individual may recognize that others might hold alternative beliefs (Borg, 2001). Belief is an individual's representation of reality that has enough validity, truth, or credibility to guide thought and behavior

(Pajares, 1992). When a person believes something, he believes it to be true or to be a reasonable approximation to the truth. Beliefs dispose and guide people's thinking and action (Borg, 2001). Individuals' beliefs strongly affect their behavior (Bandura, 1993; Nespor, 1987; Pajares, 1992; Rokeach, 1968). Beliefs are dispositions to action and major determinants of behavior, although the dispositions are time and context specific-qualities that have important implications for research and measurement (Pajares, 1992). Another feature of that definition of beliefs is, that beliefs can be conscious or unconscious. People are not always aware of the beliefs they hold. An individual can be conscious of some beliefs and unconscious about others (Borg, 2001).

Moreover, beliefs can be held on the *basis of evidence* or *without regard of evidence*. Beliefs that are held on the basis of evidence, or reasons, are open to criticism and modification as the reason for the beliefs can be questioned through the presentation of additional evidence. Beliefs that are held without regard to evidence, or contrary to evidence, or apart from good reasoning - non-evidential beliefs - are resistant to change as they are not based on reason or evidence. Non-evidential beliefs are difficult to change through rational arguments (Green, 1971).

Mansour (2009) used the concept of beliefs to characterize one's *"idiosyncratic unity of thought about objects, people, events, and their characteristic relationships that affect his planning and interactive thoughts and decisions"* (p. 26)

Philipp (2007) based on the work of Thompson (1992) and McLeod (1992), who reviewed studies on beliefs and affect, and the research on beliefs conducted since 1992, provided working definitions/descriptions of the terms related to beliefs and belief systems. Thus, she claimed that beliefs are a cognitive component of *affect*, which is defined as "*a disposition or tendency or an emotion or feeling attached to an idea or object*" (Philipp, 2007, p. 259). Affect is comprised of emotions, attitudes, and beliefs.

Emotions are *"feelings or states of consciousness, distinguished of cognition. Emotions change more rapidly, and are felt more intensively than attitudes and beliefs"* (Philipp, 2007, p. 259). Emotions may be positive or negative and are less cognitive than attitudes.

Attitudes are "*manners of acting, feeling, or thinking that shows one's disposition or opinion*" (Philipp, 2007, p. 259). They change more slowly than emotions. Attitudes, like emotions, may involve positive or negative feeling, and they are felt with less intensity than emotions, but are more cognitive in nature and more stable than emotions than emotions. One connection between emotions and attitudes is that repeated emotional reaction to an experience can result in automatizing that emotion into an attitude toward that experience (Philipp, 2007).

Beliefs are "*psychologically held understandings, premises, or propositions about the world that are thought to be true*" (Philipp, 2007, p. 259). Beliefs are more cognitive in nature than attitudes (and, hence, also than emotions), are generally stable, and are experienced with a lower level of intensity than emotions or attitudes. Beliefs tend to develop gradually and cultural factors play a key role in their development. Beliefs might be thought of as *"lenses that affect one's view of some aspect of the world or as dispositions toward action"* (Philipp, 2007, p. 259).

In an attempt to outline the relationship between beliefs, attitudes, and emotions, Rokeach (1968) argued that all beliefs have a *cognitive component* (knowledge), an *affective component* (emotion), and a *behavioral component* (action). When clusters of beliefs are organized around an object or situation and predisposed to action, this holistic organization becomes an attitude. Beliefs within attitudes have connections to one another and to other beliefs in other attitudes, so that, for instance, a teacher's attitude about a particular educational issue may include beliefs connected to attitudes about the nature of society, the community, gender, race, and even family. These connections create the values that guide one's life, develop and maintain other attitudes, interpret information, and determine behavior. The values embrace the evaluative, comparative, and judgmental nature of beliefs and replace predisposition. *Beliefs, attitudes*, and *values* form an individual's *belief system* (Rokeach, 1968).

Understanding beliefs in that way, requires making assumption about individuals' underlying states, assumptions elicited with difficulty as individuals are often unable or unwilling, for many reasons, to accurately represent their beliefs. In that sense, beliefs cannot be directly observed or measured but must be inferred from what people *say, intend,* and *do* (Pajares, 1992; Rokeach, 1968).

Philipp (2007) addressed the importance of considering beliefs together with knowledge and referred to this construct as *conceptions*. Thompson (1992) understand beliefs as a subset of conceptions and her definition of conceptions included beliefs. Conception is "*a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences*" (Philipp, 2007, p. 259). She claims that "*the distinction [between beliefs and conceptions] may not be a terribly important one*" (p. 130). The idea that beliefs is a sub-class of conceptions is adopted by other researchers too, who explain an individual's conceptions (e.g. of mathematics) as a set of certain beliefs, while others characterize conceptions as conscious beliefs (Furinghetti & Pehkonen, 2002). Many researchers, attempting to define conceptions, connect beliefs with conceptions saying that they "*use the word conceptions to refer to a person's general mental structures that encompass knowledge, beliefs, understandings, preferences and views*" (Furinghetti & Pehkonen, 2002, p. 41). However, there are other researchers who clearly distinguish the meaning of these two terms. In that sense, beliefs state something that is either true or false, thus having a prepositional nature. Conceptions are cognitive constructs that may be viewed as the underlying organizing frames of concepts. For example, the conception of a discipline and of its teaching is a set of ideas, understandings, and interpretations of pedagogical practices concerning the nature and the content of the discipline, the students and the way they learn, the teachers and the role they play in the classroom, and the context in which pedagogical practices occur (Furinghetti & Pehkonen, 2002). Additionally, Thompson (1992) understands the term conception in a global sense, not referring to a single [mathematical] idea but to the whole [of mathematics], claiming that the nature of a discipline (e.g mathematics) "*may be viewed as that teacher's conscious and subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the discipline*" (p.132)

Two constructs often closely related to beliefs are *values* and *knowledge*. Even though the relationship between beliefs and knowledge is studied thoroughly in the next section, knowledge can be considered as "*beliefs held with certainty or justified true belief. What is knowledge for one person may be belief for another, depending upon whether one holds the conception as beyond question*" (Philipp, 2007, p. 259).

Bishop, Seah, and Chin (2003) convincingly argue the differences and the similarities in the ways researchers think about *beliefs and values*. In fact, Philipp (2007,

p. 259), view values as "*the worth of something. A belief one holds deeply, even to the point of cherishing, and acts upon*".

One identified difference is that beliefs tend to be associated with a true/false dichotomy whereas values are often associated with a desirable/undesirable dichotomy. Thus, beliefs are more context-depended than values, as a true/false judgment must be made in reference to some object, while desirable/undesirable dichotomies are associated with more general, less context dependent, attributes. In that sense, beliefs are true/false statements about constructs whereas the choice of the particular constructs one finds desirable or undesirable represents one's more context-independent values. Values are often viewed as more internalized than beliefs and, hence, harder to change (Philipp, 2007). Another approach is the view of values as a subset of beliefs (Bishop et al., 2003). In that sense values may be enduring beliefs and beliefs in action (Philipp, 2007). As long as an individual is committed to a particular belief it might be said that that belief is a value for the person (Philipp, 2007), which can influence the choice of possible actions available. On the other hand, the similarities between the terms are important as the two terms are often used interchangeable. Just as people hold incompatible values, so too they hold beliefs that may conflict. Values exist within more complex systems that alone seldom determine decisions and actions. Beliefs also exist within systems (Thompson, 1992).

All in all, for this thesis, the definitions provided by Philipp (2007) and Rokeach (1968) are accepted and *beliefs* are defined as "*any understandings, premises, or propositions about the world which may be held consciously or unconsciously, are thought to be true by the individual, capable of being preceded by the phrase, 'I believe that….'*"

3.1.2 Beliefs and Knowledge

The main confusion with the concept of beliefs revolves around the distinction between knowledge and belief (Pajares, 1992). Distinguish knowledge from beliefs is a "*daunting undertaking*" (Pajares, 1992, p. 309).

For some researchers the strict distinction between knowledge and belief must not be an obsession (Furinghetti & Pehkonen, 2005). Many educators contend that distinguish between knowledge and belief is unimportant for research, but investigating how, if at all, beliefs and knowledge affect the experiences are important (Philipp, 2007).

Based on the assumption that beliefs can be considered as a form of knowledge – personal knowledge (Nespor, 1987) – a better understanding of both terms may be accomplished (Mansour, 2009). According to that approach, beliefs are perceived as "*particularly provocative form of personal knowledge*" (Kagan, 1992). Kagan argues that most of a teacher's professional knowledge can be regarded more accurately as belief claiming that knowledge is considered a belief that has been affirmed as true on the basis of objective proof or consensus of opinion. Actually, there is an interactive relationship between knowledge and beliefs (Mansour, 2009). In the interactions between knowledge and beliefs, beliefs control the gaining of knowledge and knowledge influenced beliefs.

Despite the closeness of the two terms, beliefs and knowledge, there are differences between them. The notion that a belief *is thought to be true* raises one of the more common distinctions drawn between belief and knowledge (Pajares, 1992; Thompson, 1992), with researchers often viewing *knowledge* as "*belief with certainty*" (Ertmer, 2005)

Beliefs can be held with varying degrees of conviction, whereas knowledge is generally not thought of in this way. For example, whereas one might say that he or she believed something strongly, one is less likely to speak of knowing a fact strongly (Thompson, 1992).

Ertmer (2005) referred to the distinction between knowledge and beliefs using the distinction suggested by Calderhead (1996). While beliefs refer to "*suppositions, commitments, and ideologies,*" knowledge refers to "*factual propositions and understandings*" (p. 715). Thus, after gaining *knowledge* of a proposition, we are still free to accept it as being either true or false (i.e., believe it, or not).

Emphasizing on the truth property of knowledge, Furinghetti and Pehkonen (2002) considered two aspects of knowledge: objective (official) knowledge that is accepted by a community, and subjective (personal) knowledge that is not necessary subject to an outsider's evaluation. Beliefs belong to individuals' subjective knowledge, and when expressed as sentences they might be (or might not be) logically true.

Thompson (1992) summarized three dimensions which distinguish beliefs from knowledge: the degree of inter-subjective *consensus*, the *type of argument* needed for the acceptance of beliefs and knowledge respectively, and the *relationship* of knowledge to *truth and certainty*, compared to the association of beliefs with doubts and disputes.

3.1.3 Structural Features of Beliefs

Drawing from Abelson (1979) similar efforts with artificial intelligence systems, Nespor (1987) identified six structural features of beliefs that serve to distinguish them from knowledge. Four of these features are characteristic of beliefs; *existential presumption, alternativity, affective and evaluative aspects, and episodic structure,* while the other two - non-consensuality and unboundedness- are useful for characterizing the ways beliefs are organized as systems.

Existential presumption. Belief systems often contain *propositions* or *assumptions* about the *existence* or *nonexistence* of entities. The realization of "*transitory, ambiguous, conditional or abstract characteristics into stable, well-defined, absolute and concrete entities is important because such entities tend to be seen as immutable - as beyond the control and influence*" (Nespor, 1987, p. 318)

Existential presumptions are the incontrovertible, personal truth everyone holds (Pajares, 1992). They are the taken-for-granted beliefs about physical and social reality and self and that to question them is to question one's own sanity (Rokeach, 1968). Thus, they are deeply personal, rather than universal, and unaffected by persuasion. People believe them because they are there. They can be formed by chance, an intense experience, or a succession of events, and they include beliefs about what oneself and others are like (Pajares, 1992).

Alternativity. Beliefs often include representations of *alternative worlds* or *alternative realities* (Abelson, 1979). Sometimes individuals, for varying reasons, attempt to create an *ideal*, or *alternative*, situation that may differ from reality (Pajares, 1992).

Several extreme examples of this feature may be mentioned but it is also demonstrating in real common beliefs about everyday lives. Nespor (1987) explained that a teacher in his study attempted to create the ideal learning environment she had fantasized as a child. Although she worked to shape the class to that, she had never experienced it a child. As a result, the utopian alternative with inconsistent teaching practices ended in unfinished lessons.

Essentially, alternativity refers to conceptualizations of ideal situations differing significantly from present realities. Thus, beliefs serve as means of defining goals and tasks, while knowledge systems involve if goals and the paths to their attainment are well-defined (Abelson, 1979).

Affective and evaluative aspects. Beliefs rely much more heavily on affective and evaluative components than knowledge (Nespor, 1987). Affect typically operates more or less independently of the cognition associated with knowledge. As such, knowledge of a domain can be conceptually distinguished from feelings about that domain (Nespor, 1987). Pajares (1992) likens this to the distinction between self-concept and self-esteem, between knowledge of self and feeling of worth.

Teachers often are influenced by their, sometime unrecognized, feelings about their students and often teach the content of a course according to the values they place on the content itself (Nespor, 1987; Pajares, 1992). Thus, affect and evaluation can be important regulators of the amount of energy teachers will put into activities and how they will expend energy on an activity (Nespor, 1987).

The evaluative nature of beliefs was the key factor for Nisbett and Ross (1980) to consider that generic knowledge is a structure composed of a *cognitive component*, schematically organized, and a *belief component*, possessing elements of evaluation. In that way, *beliefs* are viewed as *knowledge of a sort* (Pajares, 1992). Our perceptions are influenced by that knowledge structure – schemata, information, beliefs. Nevertheless that structure is not a reliable guide to the reality, as beliefs influence the realization of the world. Beliefs influence even the cognitive knowledge (Pajares, 1992). What may be missing from that approach is that beliefs also possess a significant cognitive component and cognitive knowledge must also have its own affective and evaluative component (Pajares, 1992).

Abelson (1979) pointed out that belief systems rely heavily on *evaluative* and *affective* components. A belief system typically has extensive categories of judgments, which are grouped into “good”, and “bad”. Knowledge systems lack such evaluations.

Episodic storage. Knowledge system information is stored primarily in *semantic networks*, whereas beliefs reside in episodic memory with stored material derived from personal experience or from cultural sources of knowledge transmission (Nespor, 1987).

Semantically-stored knowledge is thought to be decomposed into its logical constituents and organized in the form of semantic lists or associative networks. On the other hand, episodic memory is organized as personal experiences, episodes or events.

Actually, beliefs draw their subjective power from particular episodes or events that color, or frame, the comprehension of the subsequent events (Nespor, 1987). Such critical episodes and experiences gained earlier in their teaching careers played key roles in the practices the teachers in Nespor's study. Teachers learn a lot about teaching through their experiences as students. These experiences that have been referred to as *apprenticeships* to teaching or participant *observation* of teaching practices (Nespor, 1987). In that way, some crucial experience or some particularly influential teacher produces a richly-detailed episodic memory which later serves the student as an inspiration and a template for his or her own teaching practices. Such memories can be from past teachers, literature or media.

Pajares (1992) cited additional studies noting that the episodic nature of beliefs is a feature recognized in other studies too. Goodman (1988), cited in Pajares, 1992) mentioned that the teachers were influenced by *guiding images* from past events that created intuitive screens through which new information was filtered, while Eraut (1985), cited in Pajares, 1992) claimed that unsystematic personal experience in the form of *photographic images* residing in long memory played a crucial role in the process of creating knowledge.

Non-consensuality. Unlike the characteristics discussed so far that are features of individual beliefs, non-consensuality is a feature of belief *systems. "*Belief systems consist of propositions, concepts and arguments, or whatever that are recognized - by those who hold them or by outsiders as being in dispute or as in principle disputable" (Nespor, 1987, p. 321). Actually, belief systems, dissimilar to knowledge systems, do not require general or group *consensus* regarding the validity and appropriateness of their beliefs. Beliefs are characterized by a lack of agreement over how they are to be evaluated or judged (Thompson, 1992). Individual beliefs do not even require internal consistency within the belief system (Pajares, 1992).

One is generally aware that others may believe differently and that their stances cannot be disproved, whereas with respect to knowledge, one finds *"general agreement about procedures for evaluating and judging its validity"* (Thompson, 1992, p. 130).

This non-consensuality implies that belief systems are *less flexible* and *less dynamic* than knowledge systems. A characteristic of knowledge is general agreement about procedures for evaluating and judging its validity. Knowledge is acquired and adjusts according to relatively well-established plenty of argument. Contrary, beliefs are relatively static. When beliefs change, *"it is more likely to be a matter of a conversion or gestalt shift than the result of argumentation or a marshalling of evidence"* (Nespor, 1987, p. 321).

The consensus of knowledge systems is a consensus about the ways in which knowledge can be evaluated or judged. On the other hand, the non-consensuality of beliefs resides in the lack of agreement over how they are to be evaluated (Nespor, 1987). As such, knowledge systems are open to outside evaluation and critical examination, whereas beliefs are not (Pajares, 1992).

Unboundedness. Belief systems are *loosely-bounded systems* with highly variable and uncertain linkages to events, situations, and knowledge systems (Abelson, 1979). There are no logical rules to decide the relevance of beliefs to actual events and situation. Their relevance to reality defies logic (Pajares, 1992). The linkages to relevance may be bounded up with personal, episodic, and emotional experiences of the individual who hold the belief (Nespor, 1987). Actually, the unboundedness of beliefs means, that one may read belief-based meanings into events and condition where others would not see their relevance. Contrary, knowledge systems are better defined and receptive to reason (Pajares, 1992). They have well-defined domains of application, and can be broadened to encompass other phenomena only through the application of strict rules of argument (Nespor, 1987).

Given these distinctions, beliefs are far more influential than knowledge in determining how individuals organize and define tasks and problems This, then, makes them stronger predictors of behavior (Ertmer, 2005; Kagan, 1992; Mansour, 2009; Nespor, 1987; Pajares, 1992)

3.1.4 Nature of Belief Systems

The complexity of the concept of beliefs led researchers to approach them as a multi-dimensional system. They attempted to define the *belief system* by organizing its dimensions (see section 3.1.4.1), identify the types of beliefs (see section 3.1.4.2), and highlight the aspects of a belief system considering that beliefs are held in relation to one another (see section 3.1.4.3).

3.1.4.1 Definitions. There are different views about the concept of belief, depending on the point of view of the theorist or the researcher. Early approaches viewed beliefs as a uni-dimensional system, oversimplifying the concept of beliefs leading to unrealistic understanding of its basic elements (Mansour, 2009). Due to the deficiency of this approach, researchers tried to identify the concept through a multi-dimensional system. One of the first attempts espousing this multi-dimensional approach identified beliefs as consisting of eight dimensions admitting the fact that individuality and idiosyncrasy do play a substantial role in the development of beliefs (Mansour, 2009).

Two of the approaches that prevailed, introduce the concept of *belief system*s. Rokeach (1968) defined a belief system *"as having represented within it, in some organized psychological but not necessarily logical form, each and every one of a person's countless beliefs about physical and social reality"* (p. 2). This approach includes three premises for beliefs: they differ in intensity and power; they vary along a central-peripheral dimension; and, the more central a belief, the more it will resist change (Pajares, 1992).

Rokeach (1968) organized beliefs along a dimension of *centrality* to the individual. The beliefs that are more central are those for which the individual has complete consensus; those beliefs about which there is some disagreement would be less central.

According to Rokeach (1968), the centrality of a belief relates to its connectedness: *“The more a given belief is functionally connected or in communication* *with other beliefs, the more implications and consequences it has for other beliefs and, therefore, the more central the belief"* (p. 5).

3.1.4.2 Types of beliefs. Using the analogy of an atom, Rokeach (1968) described a belief system as being anchored by a nucleus, or a set of core beliefs, and outlined five types of beliefs that vary along this central- peripheral dimension: At the center are '*Type A beliefs*', that is, core beliefs that are formed through personal experiences, reinforced through social consensus, and highly resistant to change. They include beliefs about one's identity or self, and beliefs that one shares with others. *'Type B beliefs'* which are formed through direct experience but, because they are held privately, tend to be unaffected by persuasion. *'Type C beliefs'*, which relate to which authorities to trust, and although they are resistant to change, it is expected that opinions about them will differ. *'Type D beliefs'*, which are derived from the authorities in which we believe and which can be changed, providing the suggestion for change comes from the relevant authority. Finally, *'Type E beliefs'* located at the outermost edge and include arbitrary, inconsequential beliefs that are essentially matters of taste.

This conceptual model implies that individuals have diverse beliefs of differing intensity and complex connections that determine their importance (Pajares, 1992). Efforts to understand the functional connections along the central-peripheral dimensions help determine the centrality of beliefs and to define the beliefs that trigger specific behaviors (Rokeach, 1968).

3.1.4.3 Aspects of belief systems. Thompson (1992) defined a *belief system* as "*a metaphor for examining and describing how an individual's beliefs are organized*" (p. 130). Drawing upon the work of Green (1971) and Rokeach (1968), she highlighted three aspects of belief system, all related to the assumption that because a belief is never held in total isolation from other beliefs, considering how beliefs are held in relation to one another is useful (Philipp, 2007). These dimensions, characteristic of belief systems, are: *quasi-logicalness*, *psychological centrality* (the degree of conviction) and *cluster structure* (Green, 1971).

Quasi-logicalness. Some beliefs serve as the foundation for other beliefs in a *quasi-logical* structure, meaning that some beliefs might be thought of as *primary* beliefs whereas others serve as *derivative* beliefs (Philipp, 2007). This quasi-logical order is unique for each person, and it reflects the thinking and valuing of the person in question. In other words, each person has in his/her belief system his/her own logic. Actually, unlike the logically formed structure of knowledge systems, beliefs within a belief system, cannot be said to be logical, since beliefs are arranged according to how the believer sees their connections.

Psychological centrality. Some beliefs are more *important* for an individual than others. The more important beliefs are held psychologically more-central, while the others are peripheral in the individual's belief system. Thus, beliefs have their own psychological strength; the degree of conviction with which they are held (Green, 1971). The degree of conviction may vary from belief to belief. The most central beliefs are held most strongly. They are usually considered to be 100% sure, whereas the peripheral ones are less strongly held and more susceptible to change. Green (1971) points out that, primary beliefs might not necessarily be more central than the associated derivative beliefs. These assumptions can be compared with Rokeach's concept of centrality (Rokeach, 1968). This dimension of belief systems, psychological centrality, is lacking in knowledge systems, as if a person knows a certain situation, s/he is not prepared to accept a contrasting situation (Furinghetti & Pehkonen, 2002).

Cluster structure. Beliefs are held in clusters that are more or less in isolation from other clusters. *"Nobody holds a belief in total independence of all other beliefs. Beliefs always occur in sets or groups"* (Green, 1971, p. 41). One outcome of holding beliefs in this manner is that people can avoid confrontations between belief structures. This cluster structure enables individuals even to hold conflicting beliefs within their own belief system. The clustering property may help to explain contradictions and inconsistencies in one's belief system.

Summing up, beliefs are considered to be a multi-dimensional system. In this belief system, beliefs differ in intensity and power and vary along a central-peripheral dimension. The more central beliefs resist change. Individuals hold several beliefs which are organized in five dimensions, with different intensity and complex connections in this central-peripheral concept. Nevertheless, a belief is never held in total isolation from other beliefs. Beliefs are organized in clusters; some of them may be the basis for others and others are more *important* for an individual.

3.2 Teachers' Beliefs

As human beings we have beliefs about everything whether they are implicit or explicit beliefs. Our beliefs are the basis for all of the choices we make as individuals (Bandura, 1986; Richardson, 1996; Rokeach, 1968).

Teachers, like all human beings, make decisions based upon their beliefs (Bandura, 1986; Fang, 1996; Richardson, 1996; Rokeach, 1968; Thompson, 1992).“*All teachers hold beliefs, however defined and labeled, about their work, their students, their subject matter, and their roles and responsibilities*” (Pajares, 1992, p. 314).

Based upon the theory that beliefs are central to human beings' everyday decisions and actions (Bandura, 1986; Rokeach, 1968) and that there is a need not be any truth or evidence required for a belief (Richardson, 1996), it makes sense that teacher beliefs are central to their classroom decisions and actions. Teachers' decisions and actions are influenced by their beliefs, which then influence student behaviors having a significant impact upon the learning experiences provided for students (Li, 1999).

Understanding teachers' beliefs is important for understanding teachers' actions and practices in class. Bandura (1986), along with Rokeach stated that beliefs are the best indicator of an individual's decision-making. Actually, beliefs are the basis upon which individuals *plan*, *interpret*, and *make decisions* (Bandura, 1986).

Since “*humans have beliefs about everything*” (Pajares, 1992, p. 315), it is recommended to make a distinction between teachers' broader, general belief systems and their beliefs related to education. Educational beliefs can be narrowed further in order to specify what those beliefs are about - the *nature* of *knowledge*, perceptions of *self* and feelings of *self-worth*, confidence to perform certain tasks, and so on.

According to Calderhead (1996), studies investigating teachers' beliefs focus on beliefs *about learners and learning*, beliefs *about teaching*, beliefs *about subject*, beliefs *about learning to teach*, and beliefs *about self and the teaching role.* On the basis of this work, Davis and Andrzejewski (2009) recognized that the literature has focused on the beliefs most directly related to classroom practice that can be organized into categories, each of which operates on a different level ranging from *societal to personal*. They presented these beliefs as an inverted pyramid with the most global beliefs located at the top and filtering down toward to the most local beliefs teachers hold (see *Figure 2*).

Nevertheless, they pointed out that local beliefs are not of lesser importance and they do have an impact other beliefs.

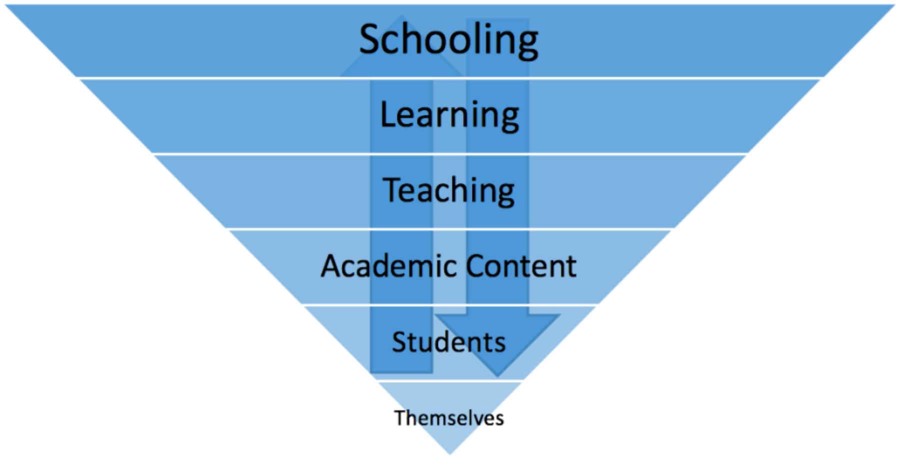


Figure 2. Classifying teachers' beliefs from global to local (Davis & Andrzejewski, 2009) (http://www.education.com/reference/article/teacher-beliefs/#B)

3.2.1 Teachers' Beliefs about Schooling

At the most global level, teachers hold beliefs about the purpose of schooling (Borg, 2001). In a holistic perspective, for some teachers, the purpose of education and school is to help all children reach their full potential in every aspect of their lives. In an essentialist perspective, some teachers believe that schools aim to help students to acquire that critical knowledge that will allow them to become productive members of society. Finally, for others, schooling should envision a new society, help students become lifelong learners enhancing their individuality (Davis & Andrzejewski, 2009).

Beliefs about the role of schooling can shape *epistemological beliefs*. Actually, beliefs about the role of education can impact *teachers' epistemological beliefs*. Epistemological beliefs refer to "*beliefs about the nature of knowledge and the processes of knowing*" (Hofer & Pintrich, 1997, p. 117). In that sense, these beliefs include those criteria that should be used in order to determine the efficacy and value of different types of knowledge. The singularity or the multiplicity of the knowledge, the need for absolute consistency of the knowledge or not, as well as the source of the knowledge (teacher, school, society, external authority) are those factors that can be employed to identify teachers' epistemological beliefs (Davis & Andrzejewski, 2009).

Epistemological beliefs influence *teachers' beliefs about learning*. Beliefs about learning refer to those related to how people learn and what it means to have learned (Davis & Andrzejewski, 2009). Teachers who believe that certain kinds of knowledge are valid, focus on having students learn those kinds of knowledge.

In the same way, epistemological beliefs affect *teachers' beliefs about teaching* and how this is accomplished. Teachers who believe that school and teachers are the only real sources of knowledge may follow behaviorist methods about learning (e.g direct instruction – teachers know and students learn). On the other hand, teachers who believe that knowledge is constructed and everyone can be a valid source of knowledge may form their classes in ways than give students the chance to focus on their own contribution to the learning procedure. Shared interactions, discussions, and dialogues are some of their techniques in an environment where students and teachers know and learn together (Davis & Andrzejewski, 2009).

3.2.2 Teachers' Beliefs about Learning and Teaching

Recent research focuses mainly on science teachers' beliefs about the nature of learning and teaching. Some interesting results and useful insights, which could be exploited in the study of Computing teachers' beliefs, are presented in this section (Klieme & Vieluf, 2009; Kordaki, 2013; Mansour, 2009; Philipp, 2007; Tsai, 2002; Wallace, 2014).

Calderhead (1996) summarized beliefs related to *teaching* and *learning* and placed teachers' beliefs into two broader categories by arguing that some teachers view teaching as a process of *direct knowledge transmission*, while others view it as a process of facilitating children's learning or as a process of constructing social relationships espousing *constructivist beliefs about learning and teaching.*

The *direct transmission view* of student learning implies that teachers' role is to: communicate knowledge in a clear and structured way; explain correct solutions; give students clear and resolvable problems; and ensure calm and concentration in the classroom. On the other hand, a *constructivist view* focuses on students not as passive receivers but as active participants in the process of learning. Teachers holding this view emphasize facilitating student inquiry, prefer to give students the chance to provide solutions to problems on their own, and allow students to play active role in learning activities (Calderhead, 1996). Teachers' commitment to one or the other perspective seem to be influenced by their *personal schooling experience*, as those experiences seem to affect their beliefs and their intentions to practice (Bandura, 1997; Tsai, 2002; Trumbull & Slack, 1991).

3.2.2.1 Teachers' beliefs about learning science. Teachers' beliefs about learning science refer to their beliefs about the *process* of learning science, what *behaviors* and *mental activities* are involved on the part of the learner, and what constitutes appropriate and prototypical learning activities (Mansour, 2009).

The direct transmission view: The direct transmission view, that can be seen to be implicit in some science teaching, is adopted by those teachers who operate as speaking tubes, sending out knowledge. Teachers who follow this transmission mode believe that knowledge is provided by public disciplines with specific content and rigorous evaluation, often viewing themselves as authorities in a subject. This type of teacher values the learner's performances according to strict and specific criteria. The role of the teacher is to evaluate and correct learner's performance according those criteria. The learner is supposed to access knowledge since he qualify himself through tests of appropriate performance (Mansour, 2009). Within the transmission view the teacher assumes that the learners do not bring relevant ideas of their own to class and that they just act as recipients of knowledge, adding the information to their memory store. In that sense, pieces of information are transferred from teacher to learner during teaching process (Mansour, 2009).

This view, echoing some teachers' beliefs about learning, is reflected in a variety of ways in practice. Especially, this belief is mirrored in: (a) teacher's approach to the *curriculum*, (b) the type of *teaching strategies* followed by the teachers, and (c) the way students are *evaluated* (Mansour, 2009).

Concerning the curriculum, this is perceived as a list of things that has to be taught. In that sense, science is presented as just a *catalogue of facts*. As far as teaching strategies are concerned, these are concentrated on the flow of information from teachers to learners. Interactions between the teacher and the learners in the class are limited to the teacher asking a series of questions and learners giving the answers. Regarding evaluation of learning, this refers to summative assessment, just checking if the knowledge has been transferred or not. The teacher is seen as being the active transmitter of knowledge, whereas the learner is initially a 'tabula rasa' and just plays a passive role in adopting and confronting with that knowledge.

The constructivist view: Unlike the transmission view, the *constructivist view* about learning science employs active participation of students in the construction of knowledge and not just the simple personal reconstruction of previously elaborated knowledge provided by the teacher or by the textbooks. From the constructivist perspective (Jonassen, 1994; Kordaki, 2003), learning is viewed as the *active construction of knowledge* in a way that gradually will expand networks of ideas through interaction with others and the environment. This perspective is reflected in: (a) the teaching strategies in class, and (b) the evaluation processes.

Regarding with the *learning strategies* which are used in science teaching, these include: (a) the wide use of hands-on investigative laboratory activities, (b) employment of cooperative learning strategies, and (c) a classroom environment which provides learners with a high degree of active cognitive involvement. *Evaluation's goal* is the activation of higher level cognitive processes. In that sense, active learners construct their own understanding, facilitated by teachers who provide stimulating and motivational experiences which challenge learners' existing conceptions and involve them actively in the learning process (Mansour, 2009, 2013).

3.2.2.2 Teachers' beliefs about teaching science. Focusing on teachers' beliefs about teaching science and how this is accomplished, Bell and Gilbert (2005) documented two approaches in teaching. The first refers to the belief that the role of a teacher, as the only expert, is to present the knowledge directly to students in a deliberately and logical sequence. The second is based upon the belief that knowledge is constructed by individuals, and that the role of the teacher is to be a facilitator who allows students to assimilate, reconstruct, extend or replace their existing knowledge.

In fact, teachers' beliefs about science teaching are extremely varied (Mansour, 2013). Some teachers believe in teaching students by lecturing or direct teaching.

Others use co-operative learning or inquiry espousing constructivist views about teaching. However, the majority of science teachers are more likely to mix features of science teaching methods. A teachers' belief about science teaching is more likely to include various aspects of several modes of teaching than it is to fit perfectly into the description of a single model (Mansour, 2009).

3.2.2.3 Personal schooling experience as a guide. Researchers have tried to find out why teachers espouse one or another perspective (Bandura, 1997; Tsai, 2002; Trumbull & Slack, 1991). Bandura (1997) believes that behavior such as direct knowledge transmit or constructivist teaching was learned through a process called observational learning. Teachers developed an idea of how a teaching perspective works without actually performing it. The success or the failure of each perspective can be used as a guide for future action. So teachers beliefs and practices (or at least intentions to practice), can be affected by their experiences of university teacher education, of life-in-school experiences, of past school experiences, and of life-out-of-school experiences, turned into practice, or at least into teachers' intention to practice.

Tsai (2002) argues that the beliefs of many teachers, who hold traditional views of teaching science, learning science, and the nature of science, may stem from the problem of their own school science experience. Science classes, lab exercises, and other relevant activities in teacher education programs may have reinforced traditional views. In the same way, Trumbull and Slack (1991) suggest that teachers fail to develop constructivist-oriented ideas about teaching and learning because they have all experienced success in the existing educational environments.

Evidence from other research strengthens also this assumption (Richardson, 1996; Stuart & Thurlow, 2000). Stuart and Thurlow (2000) analyzed the beliefs of preservice teachers enrolled in a mathematics and science methods course. Twenty-six preservice teachers were asked to examine their beliefs and the impact these beliefs had on classroom practice. The researchers concluded that the preservice teachers' beliefs' about teaching were heavily influenced by their childhood experiences.

In a review of research on attitudes and beliefs in learning to teach, Richardson (1996) reported that preservice teachers' beliefs about teaching result from personal experience, schooling and instruction, as well as formal knowledge. However, she concluded that these beliefs could be changed or enriched because of experience and reflection upon that experience.

To *sum up*, teachers hold mainly two kinds of beliefs about teaching and learning science. Some of them approach learning as a process of direct knowledge transmission supporting direct teaching as the appropriate teaching practice, while others espouse constructivist beliefs about learning highlighting a more facilitating role for the teachers. Those beliefs may stem from their personal school experiences. In most cases, teachers' beliefs are reflected in their practices in several ways: their approach to the curriculum, their teaching strategies and their assessment methods.

3.2.3 Teachers' Beliefs about Academic Content

Teachers' beliefs about academic content, regarding *status*, *stability*, *sequence*, and *scope*, form their practices. The beliefs they hold define the concepts they emphasize; the way they plan and organize the teaching material, the student understandings and misconceptions they anticipate, as well as their educational decisions (Davis & Andrzejewski, 2009).

3.2.4 Teachers' Beliefs about Students and Themselves

Teachers' beliefs about their students refer to what it means to be a student, how students should relate to teachers, the impact of student differences on classroom practice and culture (e.g. gender, race, caste) (Davis & Andrzejewski, 2009).

In a quantitative study, Solomon, Battistich, and Hom (1996) assessed the attitudes, beliefs, perceptions and classroom practices of 476 teachers in 24 urban and suburban elementary schools through the use of teacher questionnaires and classroom observations during the course of a school year. The researchers reported that teachers' beliefs were consistent with their teaching practices when school poverty level and students' achievement are considered. Among the findings from the data, researchers found that teachers in economically disadvantaged schools emphasized teacher authority and control rather than student autonomy and constructivist approaches. They pointed out that teachers in poor communities provided less engaging activities and saw themselves as having less influence than teachers in more affluent communities.

In some cases teachers' beliefs about their students may be in conflict with their students' needs. Generally, teachers' beliefs about their students may prevent them from recognizing and appropriately responding to student behavior, concealing the actual motives, values, and needs of their students. Conflicts between teachers' and students' beliefs may have negative instructional and interpersonal consequences.

At the most local level, teachers hold beliefs about themselves. These beliefs refer to: who they are *in relation* to *curriculum*, *colleagues*, and *students*; *perceived strengths and weaknesses*; *values*; *self-efficacy*; and *responsibility* (Davis & Andrzejewski, 2009). These beliefs may be specific domain and hierarchically organized. Thus, a teacher may believe that he is an expert in the field and a great instructor, but has issues with the class management. Each of these domains may weigh differently for a teacher.

Specifically, teachers' self-efficacy beliefs seems to play a key role in the learning process (Bandura, 1997). In a study of teachers' beliefs about *self-efficacy*, Ashton and Webb (1986) used questionnaires, interviews, classroom observations, and student records to determine if there was a relationship between teachers' self-efficacy and student achievement. Forty-eight high school teachers were included in the study. Researchers concluded that there is a relationship between teachers' self-efficacy beliefs and their teaching behaviors as well as between teachers' self-efficacy beliefs and student achievement in both reading and math. In fact, teachers' self-efficacy influenced their teaching behaviors; such as their use of praise and whether or not they were task-oriented.

3.3 Teachers' Beliefs and Classroom Practices

For decades, researchers have focused on identifying factors that shape teachers' practices in the classroom (Mansour, 2013). Some of these factors include beliefs about: teaching/student learning (Mansour, 2009); students (Davis & Andrzejewski, 2009), context of teaching (Kang & Wallace, 2005); the nature of science and the subject matter (Davis & Andrzejewski, 2009; Mansour, 2009); the curriculum (Mansour, 2009) and socio-cultural contexts (Ajzen, 2002; Mansour, 2009; Vygotsky, 1980).

Research in STEM fields has revealed the interactive relationship between beliefs and practices (see section 3.3.1). Yet, there is evidence of inconsistencies between beliefs and teaching practices (see section 3.3.2), indicating that teachers' beliefs do not necessarily have a direct causal effect on their actions (Mansour, 2013). Nevertheless, research in STEM argues that teachers' beliefs and practices cannot be examined out of socio-cultural context they take place, which explain possible observed inconsistency between beliefs and practices (see section 3.3.3). Focusing on Computing, despite the fact that teachers beliefs' regarding the use of technology (ICT) in teaching and learning have been explored, studied examining specifically CS teachers beliefs are scarce (see section 3.3.4)

3.3.1 Beliefs and Practice: An Interactive Relationship

A great deal of empirical evidence has established the significance of beliefs for understanding teacher behavior (Calderhead, 1996; Clark & Peterson, 1986; Pajares, 1992). Teachers' beliefs can influence classroom practices through interpreting meanings in the classroom (Thompson, 1992).

A wealth of research has indicated that teachers' beliefs about teaching and the learning of science influence their teaching practices (Calderhead, 1996; Mansour, 2013; Pajares, 1992). Nespor (1987) explains how beliefs become personal pedagogies or theories to guide teachers' practices. Teachers' beliefs play a major role in defining teaching tasks and organizing the knowledge and information relevant to those tasks (Mansour, 2009).

Pajares (1992) mentioned several sources in support of the presumption that "*beliefs are the best indicators of the decisions individuals make throughout their lives*" (p. 307). He cited research on teachers' beliefs and argued that there is "*a strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices*" (p. 326). In describing this relationship, Pajares noted that, "*the beliefs teachers hold influence their perceptions and judgments, which in turn, affect their behavior in the classroom…"* (p. 307). In his view "*educational beliefs of pre-service teachers play a pivotal role in their acquisition and interpretation of knowledge and subsequent teaching behavior*" (p. 328), concluding that beliefs are "*far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior*" (p. 311).

Kagan (1992) cited significant evidence supporting the relationship between beliefs and practice pointing out that empirical studies have yielded quite consistent findings, "*a teacher's beliefs tend to be associated with a congruent style of teaching that is often evident across different classes and grade levels*" (p. 66).

Haney, Czerniak, and Lumpe (1996), based their work on the theory of planned behavior, and argued that teachers' beliefs are significant indicators of their behaviors in the classroom. Teachers' beliefs about the subject matter have also been found to influence their decisions about what to teach, what to leave out, and how much class time to devote to a particular theme.

In addition, teachers' beliefs about the nature of science influence their instruction. Brickhouse, Bodner, and Neie (1987) found that teachers who believed that quantification differentiates science from non-science emphasized on quantification in instruction, while others, who believed that science is discovered, used this belief as a guide for discovery labs, giving the opportunity to their students to discover knowledge. In another study concerning secondary school teachers, one teacher who viewed theories as truths wanted his students to know about the major scientific theories, while another teacher who considered theories as tools insisted that his students should be able to use them to solve problems. A third teacher who perceived the scientific method as a linear and rational process leading on doubtless truth emphasized on science that required following directions to get correct answers (Brickhouse, 1990).

In a literature review regarding the relationship between teacher beliefs and practices, Fang (1996) reported that teachers' theories and beliefs are an important part of their general knowledge. These beliefs can influence teachers' expectations of student performance as well as teachers' theories about teaching and learning. These, in turn, can have significant impact on academic performance and student learning.

Northcote (2009) realized another literature review concerning teachers' educational beliefs and practices in teacher education contexts, and revealed that there is extensive evidence of the strong link between educational beliefs and educational practice. The strength of the beliefs-practice relationship has been documented by a range of researchers, especially in the context of teacher education, suggesting that teachers' practical experiences can influence their beliefs in general ways; teachers' beliefs affect their use of specific instructional strategies that, in turn, impact on the quality of student learning; and teachers' practical approaches to teaching and their teaching intentions can be influenced by their conceptions of teaching (Northcote, 2009). These findings indicate that teachers' practical approaches to teaching and learning are linked to their educational beliefs.

Northcote (2009) investigated the teaching and learning beliefs held by teachers and students who taught and learned together at a large Australian metropolitan university. Three of the five classes involved in the study were enrolled in teacher education courses, one class in a CS course and one in a multimedia course. She noticed high levels of similarity between teachers' and students' beliefs, and concluded that students' and teachers' educational beliefs influence their learning and teaching practices. Specifically, in the case of teacher education, the correspondence between teachers' teaching practices (teaching strategies, course design considerations, interactions, and assessment techniques) and students' learning practices (study strategies, assignment completion, research techniques and contributions to learning activities) was more evident.

Mansour (2013) investigated 162 preparatory science teachers' epistemological beliefs and beliefs about teaching and learning science, examining to what extend these beliefs correspond to their practices. His study revealed consistency between science teachers' traditional pedagogical beliefs and their practices. Concerning teachers' epistemological beliefs, their admitted beliefs were consistent with their preferred ways of teaching.

Additional research argues that teachers' epistemological beliefs influence their instructional methods as well as the degree of consistency among teachers' epistemological beliefs and their actual practices in the classroom (Tsai, 2002). Kang and Wallace (2005) found that teachers' epistemological beliefs were closely connected to their pedagogical approaches to achieving different teaching goals.

Despite the widely accepted notion that beliefs influence behavior, there is a debate whether this relationship is unidirectional or actions as well influence beliefs (Mansour, 2009). Some researchers have noted that reflecting on practice can change beliefs. Mansour (2009; 2013) cited studies indicating that teachers' beliefs changed after participating in in-service programs, or attending workshops or participating in focus groups. Implicit beliefs became explicit after reflection. Beliefs and practices interacted and adjusted. As the teachers became more aware of their beliefs, they were more willing to implement a specific practice in their classroom. In that sense, the relationship between beliefs and practice is interactive (Mansour, 2009).

3.3.2 Inconsistencies between Beliefs and Practices

Because of the complexity of teachers' beliefs systems, inconsistencies between teachers' beliefs and their teaching practices may appear (Mansour, 2013). Actually, there is a set of research indicating that teacher practices is *not always consistent* with their beliefs (Calderhead, 1996; Fang, 1996; Philipp, 2007)

Raymond (1997) noted inconsistencies between beliefs and practices in the case of a female math teacher. Her practices were more in line with her beliefs about mathematics than her beliefs about mathematics teaching and learning. Despite the importance attributed to mathematics, inconsistencies between her espoused beliefs and her practice were also explained by general educational issues, such as time constraints, resources, standardized tests, and students' behavior.

Ertmer, Gopalakrishnan, and Ross (2001) reported that teachers' beliefs about classroom technology use did not always match their classroom practices. Despite the fact that most of the teachers described themselves as having constructivist philosophies, they implemented technology in ways that might best be described as representing a mixed approach. Sometimes they engaged their students in project-based work, while other times students were asked to complete tutorials, practice skills, and learn isolated facts. Teachers' explanations for these inconsistencies often included references to curricular requirements or social pressure exerted by parents, peers, or administrators.

Kang and Wallace (2005) worked with three experienced secondary school science teachers and concluded that teacher's epistemological beliefs were not always clearly connected to their practice. Brown and Melear (2006) analyzed the connections between the teachers' communicated beliefs and observed practice regarding teachers' actions and found inconsistencies between interviews and observational data.

More recently, inconsistencies between teachers' beliefs and their practices have also been reported (Mansour, 2013). Science teachers with mixed beliefs (traditional – constructivist) had traditional practices. In addition, teachers who held mixed beliefs were student-centered in how they viewed themselves as teachers, but were teacher-centered in their classroom actions, without realizing the inconsistency.

Researchers who mentioned inconsistencies between teachers' beliefs and practices have attempted to explain them (Philipp, 2007). One approach taken by researchers to explain inconsistencies is to examine whether particular beliefs within a beliefs system are *more central or primary*, playing a greater role in influencing practice, than other beliefs. According to Munby (1982), when beliefs about a particular subject area are inconsistent with a teacher's practice in that area, it may just be that "*different and weightier beliefs are the cause*" (p. 216), a view consistent with that of researchers who have investigated belief structures (Nespor, 1987; Pajares, 1992). Another approach is to study whether a teacher's perspective on his or her practice might help explain the apparent contradiction (Mansour, 2013). Ajzen (2002) suggests that there are many elements that cause a mismatch between beliefs and practices. Real-life factors, such as learner behaviors, time, resources, and course contents, have an impact on the degree of belief-practice consistency. Especially socio-cultural context within practice can cause inconsistencies. Mansour (2013) attributed the consistencies and the inconsistencies between teachers' beliefs and practices to contextual factors, which can cause conflict and prevent teachers from realizing their beliefs in actual practice.

3.3.3 The Role of Socio-Cultural Context

While it has been accepted that the study of beliefs is important to the understanding of teachers' practices in the classroom, a number of studies (Fang, 1996; Mansour, 2009, 2013; Nespor, 1987; Pajares, 1992) argue that teachers' beliefs and practices should be studied within a framework that is aware of the influence of culture. The formation of teachers' beliefs is affected by the culture as "*the contexts and environments within which teachers work, and many of the problems they encounter, are ill- defined and deeply entangled [and] beliefs are peculiarly suited for making sense of such contexts"* (Nespor, 1987, p. 324). Teachers' practice is a reflection of their culture and cannot be properly understood without reference to that culture (Mansour, 2013). In this sense, teachers' beliefs and practices cannot be examined out of context, but are always situated in a physical setting in which constraints and external influences may appear, such as the classroom environment, the school, the curriculum, and the community (Mansour, 2009; 2013). Viewing teachers' beliefs as separated from the broader contextual issues "*is ill-advised and probably unproductive*" (Pajares, 1992, p. 326).

The strong influence of the educational social – cultural context can explain possible observed inconsistency between beliefs and practices (Mansour, 2013). Ernest (1989) partly attributed inconsistencies between mathematics teachers' beliefs and practices to the powerful influence of the social context that resulted from the expectations of others (including students, parents, peers and superiors). Another factor suggested was the institutionalized curriculum (the curricular scheme, the system of assessment, and the overall national system of schooling). According to the researcher, these two constraints limited teachers affecting the achievement of the models of teaching and learning mathematics. The impact of the social context was so powerful that despite having differing beliefs about mathematics and its teaching, teachers in the same school were often observed to adopt similar classroom practices.

Fang (1996) described a number of studies in which researchers found little relationship between teachers' beliefs and their classroom practices, and suggested that there may be inconsistencies between teachers' beliefs and practices due to the complexities of classroom life. Within this context, teachers may be unable to provide instruction that is aligned with their theoretical beliefs. Their theoretical beliefs could be occasional and demonstrated in instructional practices only in relation to the complexities of the classroom.

When Hoyles (1992) viewed teachers beliefs as decontextualized, she observed inconsistencies, but when her view of beliefs became more contextualized and situated, she could explain apparent inconsistencies by considering the circumstances and constraints within settings.

Sztajn (2003), studied two teachers who held similar beliefs about mathematics but taught in very different contexts and differed in their teaching. She concluded that teachers' beliefs about mathematics were insufficient for explaining the actual teachers' practices. Only after considering the teachers' beliefs about children, society, and education was she able to read teachers' practices.

The contextual constrains are identified in several later science studies as well (Mansour, 2009; 2013). In fact, classrooms work within school and realize contextual constraints related to school, constraints that specify the roles, status, and degree of autonomy that teachers and students have. The social norms of the school community influence how teachers believe their practices will be perceived (Mansour, 2013). In some cases, science teachers, are reluctant to teach controversial issues regarding science and society as they believe that they lack outside support from parents and the community, as well as internal support of faculty and peers (Pedersen & Totten, 2001)

Summarizing this section, it can be argued that the relationship between teachers' beliefs and their practices are far from straightforward. Beliefs can have indirect but strong effects on teaching practice, and be often context-dependent, so that they have differing strengths in differing contexts. Actually, the relationship between teachers' beliefs and practices is complicated; it is *dialectical* rather than *unilateral* (Mansour, 2013). In fact, there is a *complex interaction* between teacher beliefs, which are socio-cultural construct, and teacher actions, which take place in the social arena. In a way to put it, teacher practices represent one aspect of a teacher's beliefs and should not be perceived as a separate entity from their belief system as a whole (Mansour, 2013).

3.3.4 Computing Teachers' Beliefs and Practices

Pedagogical beliefs of teachers concerning the technology integration in class have been extensively investigated in recent studies (Ertmer, 2005, 2006; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Ertmer, Ottenbreit-Leftwich, & Tondeur, 2014; Park & Ertmer, 2007). The enhanced role of ICT in teaching and learning process is acknowledged by many teachers, in primary and secondary education, with the intention to utilize it in practice (Kordaki, 2003; Ertmer et al., 2014).

Despite the excessive study of teachers beliefs' and use of technology to support teaching and learning, studies regarding Computing teachers are scarce.

Recent research on Computing teachers' beliefs has focused on: their pedagogical beliefs (Fessakis & Karakiza, 2011); their beliefs about teaching and learning (Kordaki, 2013); their beliefs about successful and unsuccessful teaching (Carbone, Mannila, & Fitzgerald, 2007); their beliefs about teaching using digital technology (Fessakis & Karakiza, 2011; Lameras, Levy, Paraskakis, & Webber, 2012; Shuhidan, Hamilton, & D'Souza, 2010); and their beliefs about assessment (Fessakis & Karakiza, 2011; Shuhidan et al., 2010). In some cases, Computing teachers' beliefs were investigated along with their practices (Kordaki, 2013).

Fesakis and Karakiza (2011) investigated the pedagogical beliefs of Computing teachers, exploring teachers' preference between the traditional knowledge-transmission oriented teaching and the constructivist consistent teaching. They examined four dimensions; *the curriculum, the teaching approach, the students' work and the assessment*, that can be used to distinct traditional and the constructivist approaches. According to the researchers, Computing teachers in Greece, have beliefs which consist of a *mixture* of traditional and constructivist principles. Concerning students' work they revealed constructivist views and had mixed views about the assessment process. Regarding the curriculum-content, teachers adopted the traditional approach holding traditional beliefs. The research revealed that *contextual* and *personal* beliefs constrained the implementation of a constructivist framework for teaching. The *contextual factors* that were recognized are: the school context, school teachers' supportive role, school students' motivation and knowledge level, Computing as a subject of study, and availability and accessibility of learning sources. On the other, *personal factors*, such as teachers' interpretations of Computing curriculum and pre-understanding of existing school practices, their perceptions of Computing as school subject, as well as, their conceptions about pedagogy and pedagogical practices may affect the implementation of a constructivist approach in class.

Carbone et al. (2007) investigated the conceptions of academic Computing teachers about successful and unsuccessful teaching. Computing academics realize successful teaching in terms of *feeling successful*, *good delivery*, and *developing students' thinking*. On the other hand, concerning unsuccessful teaching, Computing teachers believe that it may be due to the fact that teachers lack *skills* and/or *support*, students lack *responsibility* and/or *understanding*, and the *complexity* of the Computing domain.

Computing academics' conceptions of teaching using digital technology, specifically, Virtual Learning Environments (VLEs), in blended settings have also been investigated (Lameras et al., 2012; Lameras, Paraskakis, & Levy, 2008). These studies revealed that digital technology was used to support information transfer; application and clarification of concepts; exchange and development of ideas, resource exploration and sharing; collaborative knowledge-creation, and development of process awareness and skills. Depending on the way that digital technology was utilized, different teaching approaches were revealed: '*teacher-focused and content-oriented'*, '*student focused and content-oriented*', '*student-focused and process-oriented'*.

Kordaki (2013) studied Computing teachers' beliefs about themselves as teachers as well as about basic issues regarding teaching and learning Computing. Twenty-five Greek Computing teachers were interviewed and observed in class. Kordaki (2013) concluded that the majority of Computing teachers hold various *empowering* and *constraining* beliefs regarding Computing and its teaching and learning, as well as about themselves as Computing teachers. Actually, some of their beliefs empowered teachers to realize constructivist approaches while others may constrained them to traditional behaviorist practices. A mix of empowering and constraining beliefs seemed to co-exist in the majority of Computing teacher minds. In the same study, possible associations between Computing teachers' beliefs and their actual teaching practices were also investigated. According to the results, all teachers' beliefs had been reflected in their actual practices. In fact, the consistent empowering beliefs that reflected in their practices included problem solving and collaborative settings that encourage the development of students' critical thinking skills. On the other hand, inconsistent beliefs were associated with teaching practices where at least one constraining belief was reflected and appeared to play a key role. This study also revealed that teachers' descriptions of their practices in the interviews differed from their actual practices when observed. This fact could imply that teachers are not fully aware of their practices (Pajares, 1992; Furingetti & Pehkonen, 2002; Ertmer, 2005), or they may believe that their practices reflect what they said during their interviews either there are other core beliefs or contextual and societal factors

(Mansour, 2009) that constrain them to implement their conceptual designs for their lessons in real practice.

Another study investigated Computing teachers' perceptions of their goals and experience of teaching basic aspects of algorithmic problem solving, revealing that teachers perceived their students as having a different perspective on the domain, on what constitutes a beneficial approach to problem-solving and on the nature of satisfactory solutions (Kolikant, 2011).

Teachers' perceptions towards multiple choice questions in summative assessment of novice programming ability were also investigated using both quantitative and qualitative data (Shuhidan et al., 2010). Most of the instructors believed that summative assessment is, and is meant to be, a valid measure of a student's ability to program. In that sense, the instructors would not expect a novice who could program to fail a summative assessment test nor would they expect a person who could not program to pass the test. Regarding multiple-choice questions, most instructors reported confidence in using them believed that they provide a means of testing a low level of understanding, a few suggested that they are easy to answer, and others refused to use them at all (Shuhidan et al., 2010).

Student teachers' beliefs about creativity, creative outcomes and factors related to creativity in CS were also investigated (Romeike, 2010). Student teachers described CS as a highly creative subject involving creative processes. They perceived software development as creative and believed that programming courses allow and encourage students to be creative, increase their motivation and interest. For them computers and programming software are appropriate tools to support creativity. Creativity is considered as important and as a key to success; an ability that could be developed rather than seen as a rare gift (Romeike, 2010).

Apart from teachers' beliefs, beliefs of faculty in Computing regarding the nature of CS were also investigated. Lewis, Jackson, and Waite (2010) collected responses to 32 questions about attitudes and beliefs regarding CS from 13 Computing faculty at the University of Colorado at Boulder. They believed that CS is more than memorizing solutions; doing things right is more important than just getting a solution; Computing is creative and valuable; and much work in Computing is collaborative thus, students have to develop collaborative skills.

3.4 Gender-related Teachers' Beliefs and Practices

Several studies have been conducted on gender-related teachers' beliefs within STEM fields e.g. (Chionidou-Moskofoglou & Chatzivasiliadou-Lekka, 2008; de Kraker-Pauw et al., 2016; Fennema, Peterson, Carpenter, & Lubinski, 1990; Garrahy, 2003; Ghosh, 2004; Gul, Khan, Mughal, Rehman, & Saif, 2012;Li, 1999, 2004; She, 2000; Tiedemann, 2000a, 2000b, 2002; Watson et al., 2015). Most of these studies focus on gender issues and teachers' beliefs within mathematics education. Eventually, an analysis model has been developed for the study of gender-related teachers' beliefs and practices in the STEM fields (see section 3.4.1). Regarding teachers' gender-related beliefs and practices in the Computing field, research focuses mainly on the ICT use investigating teachers' beliefs from several disciplines who just use technology computers as a tool in class (see section 3.4.1). The studies from the STEM fields presented in this section could be exploited as a reference point for the study of Computing Teachers' gender-related beliefs and practices.

3.4.1 An Analysis Model in STEM Fields

Li (1999, 2004) explored possible relationships between *teacher variables* and *student variables* with respect to gender. She offered a framework for organizing research on gender issues and teachers' beliefs, presenting a model of teacher beliefs and gender differences (Li, 1999). In 2004, based on that model and the work of Fennema (1990), she developed an enhanced model for the study of gender issues (Li, 2004). Her work is based upon teachers' belief within mathematic education, but this framework can be used to conceptualize the organization of the field and identify the different variables within STEM education. This model can serve as a heuristic device that reflects the related literature in the field and as a theoretical framework for future research. In the model, illustrated in Figure 3, two entities are depicted, *Teacher* and *Student*, in which there are specific variables. For teachers' side: *teacher gender, teachers' beliefs, teachers'* *decisions, and classroom practices;* for students' side: *students' achievements; students' behavior and students' beliefs*. These variables reflect the state of the field in research on gender issue in relation to teachers and the researchers' conceptualization of the field, suggesting theoretical connection between teacher beliefs and student beliefs in relation to gender. The arrows in the model indicate the relationships between the entities and the variables.

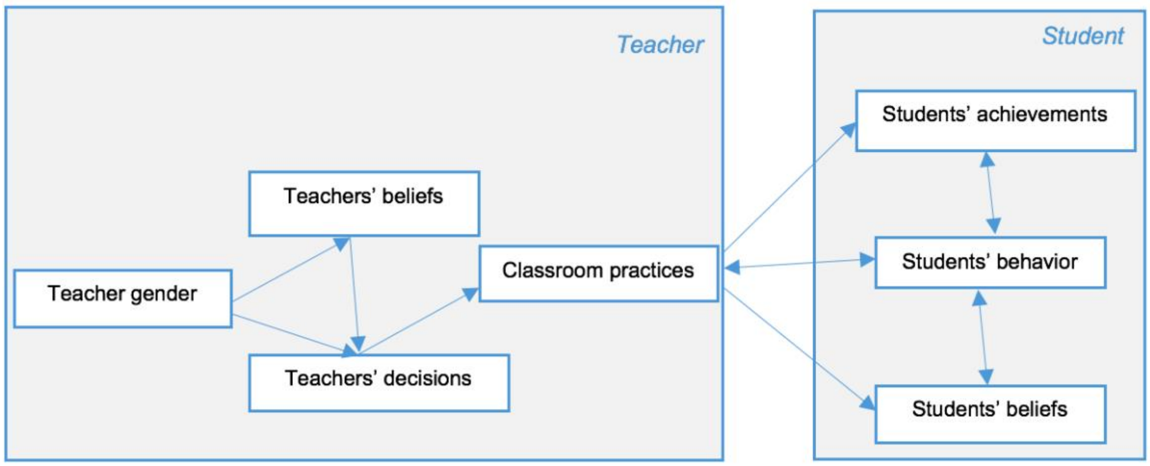


Figure 3. Teachers' beliefs and gender differences model *(Li, 2004)*

According to the model, with respect to teacher gender, as shown by the arrows, the causality is unidirectional, that is teacher gender affects teacher beliefs and decisions. The impact of teacher gender on student attitudes and beliefs, and gender-related teacher-student interactions are reported in the literature (Li, 1999, 2004). Additionally, teachers' decisions are influenced and even determined by teachers' beliefs. The decisions, in turn, define teachers' classroom practices. These four teachers' variables (teachers' *gender*, *beliefs*, *decisions* and *classroom practices*) affect students' *beliefs*, *behaviors*, and *achievements*. Actually, teachers' variables influence students' beliefs and achievements unidirectional, as shown by the arrows, while they affected and are affected by students' behaviors. The double-arrowed line allow for the possibility of a bi-directional causality between teachers' beliefs, decisions, and classroom practices and students' behaviors. Alternatively, students' behaviors have an impact on teacher beliefs and decisions, and ultimately their classroom instruction. Regarding students' variables, the relationship between students' beliefs and behaviors is bi-directional, meaning that beliefs can affect and be affected by behaviors and vice versa. Similarly, the relationship between students' behavior and achievement is bi-directional. Ultimately, the model implies that six out of the seven variables depicted (apart from teacher gender) are dynamic and subject to change.

Several studies within the field of STEM education enhance the notion that this model correspond to reality. The majority of the studies investigating teachers' gender-related beliefs in the STEM fields focuses on (M)athematics teachers . Relevant studies on teachers from the remaining STE fields are scares. Regarding (S)cience and (E)ngineering, studies seek to highlight science and engineering teachers' gendered beliefs (de Kraker-Pauw et al., 2016; She, 2000), while (T)echnology, in relevant studies, is approached in a generalized field, under the term ICT (Information and Communication Technology) (Catalyst, 2004; Ertmer, 2005; Vekiri, 2010, 2013b). In that sense, research does not focus on teachers' gender related beliefs who actually teach technology and Computing, but on teachers who use technology and computers as a tool in class. Actually, research on Computing teachers' gender-related beliefs have not been reported.

The numerous studies on gendered beliefs of (M)athematics teachers can be exploited as a framework and a reference point for future research in the 'unexploited STE fields' in general, and the gender-related Computing teachers beliefs in particular. Research in the field is discussed in the rest of this section according to the model presented above.

3.4.1.1 Teacher gender. In her review of the related literature, Li (1999) demonstrated that teacher gender is a factor that impacts their beliefs and practices, which in turn, influences their students. Li's (1999) review revealed that teacher gender influences student variables such as student performance, behaviors, and beliefs. At the same time, teacher gender also influences teacher variables such as: teacher classroom practices (e.g., teacher-student interaction) and beliefs. Regarding learning techniques, Li noted that female teachers tend to be more student-centered, indirect and supportive of students than male teachers. Female teachers tended to promote learning environments that are more student-oriented, facilitative and effectively driven. Also female teachers appeared to use class discussion more frequently, encourage collaboration and affective learning techniques rather than other instructional behaviors (Li, 1999). Teaching /

learning strategies may play an important role for male and female students, as this is directly related to gendered learning styles, as discussed below. Male teachers seem to exhibit stronger gender-related beliefs than female teachers (de Kraker-Pauw et al., 2016). Furthermore, there is some evidence that female teachers tended to have stronger '*egalitarian views*' about gender roles than male teachers do although this is not a consistent finding (de Kraker-Pauw et al., 2016). A more recent study on differentiated male and female teacher expectations, and the influence of teacher–student gender match and mismatch on teacher expectations of student achievement in mathematics, found that teacher gender was associated significantly with teacher expectations of student achievement in mathematics (Watson et al., 2016). Ultimately, teacher gender is an important factor in studies concerning gender issues and should be considered in future research.

3.4.1.2 Teachers' beliefs about gender differences. Gender-related beliefs concern the different abilities, characteristics or traits that are associated with girls and boys (Tiedemann, 2002). Since teachers' beliefs can affect their decisions in the educational setting and their classroom practices, their gender-related beliefs about the abilities and the learning behavior of boys and girls may sustain existing, possibly undesirable, situations with regard to the expectations and education of boys and girls affecting their achievements. Several studies discussed the gender-specific character of various subjects, but STEM seems to be a field particularly likely to evoke associations with gender (de Kraker-Pauw et al., 2016).

Teachers' beliefs about gender differences: abilities and characteristics. STEM teachers, especially male teachers, seem to hold stronger implicit gender-related beliefs linking male gender to STEM abilities (de Kraker-Pauw et al., 2016). A wealth of studies in STEM field supports that notion.

Fennema et al. (1990) investigated teacher beliefs in relation to gender and mathematics. They studied the beliefs of thirty eight first grade female teachers in twenty four schools in the United States. Teachers were asked to recognize two of their most and least successful male and female students and to describe their characteristics. The results of this study show that teachers' beliefs about male and female students in mathematics differed. Teachers perceived male students as being their best students and were most inaccurate in selecting their most successful students. They tended to attribute males' success in mathematics to *ability* more often than they did for females. On the contrary, for females success was attributed to *effort*. This attribution for female students is believed to have negative impact on female students' achievement (Li, 1999). What is more, teachers in that study believed that their best male students, when compared to their best female students, were more *competitive*, more *logical*, more *adventurous*, and independent, while they tend to overrate males' capability and to underrate the females'. In general, "teachers' beliefs are somewhat negative about females and the learning of mathematics" (Fennema et al., 1990, p. 184).

In a relevant study, regarding science education in general, teacher considered the males are more competent in tasks that require mental or abstract operations (analyzing, synthesizing, hypothesizing, evaluating, interpreting, questioning), while girls are apparent as more proficient in talent related to completing a task (observing, measuring, communicating, graphing, manipulating equipment and materials) (Shepardson & Pizzini, 1992).

Jussim and Eccles (1992) studied teacher expectations, constructions and reflection on student achievement and concluded that teacher perceptions were generally consistent with stereotypes of gender differences: boys have more talent and girls compensate their natural disadvantage by working *harder*.

In line with these finding, Tiedemann's (2000a) study revealed stereotypical teachers' beliefs on gender differences in math achievement. The subjects of his study, fifty two third-grade and fourth-grade German *mathematics teachers,* were each asked to choose six students from their class, three boys and three girls. In both gender groups, one student had to be from upper performance level, one from medial performance level, and one from low performance level. After this classification, the teachers were given a survey for each of their selected students regarding: students' abilities and effort; casual attributions of multiple achievement outcomes; and expectations of future achievements. Tiedemann highlighted specific gender-biased beliefs of elementary mathematics teachers in his study. Teachers thought that: average achieving girls were less logical than equally achieving boys; girls profited less than boys from additional effort; girls exerted relatively more effort to achieve the level of actual performance in mathematics;

mathematics was more difficult for average achieving girls than equally achieving boys. With regard to girls, teachers attributed unexpected failure more to *low ability* and less to lack of effort than boys.

In a later study, Tiedemann (2002) examined the effects of teachers' gender-role-stereotypes on their perceptions of their children's mathematics ability. Forty eight German elementary school teachers of 288 students were surveyed in this study, and the results supported the hypotheses that teachers' gender stereotypes have a clear effect on their beliefs about their students' ability and effort resources.

Built upon Tiedemann (2000a, 2002) investigations of teachers' gender-related beliefs in mathematics and science, Ghosh (2004) investigated high school teachers' gender-related beliefs in mathematics education. The participants for her study were five mathematics teachers from a high school in the United States. Four of them were females. By using a combination of teacher surveys, formal and informal interviews with the teachers, classroom observations, and videotapes of teacher-student interactions, the researcher employed different data sources to validate and crosscheck the findings. The results of the study revealed that teachers believed that medial and low achieving girls were less logical than equally achieving boys, while medial and low level girls exerted relatively more effort to achieve the level of actual achievement in mathematics.

A later qualitative study in Greece (Chionidou-Moskofoglou & Chatzivasiliadou-Lekka, 2008) investigated ten teachers' - five male and five female, teaching 3rd to 6th Grade classes - perceptions of their students' mathematical abilities, effort- resources, career prospects, general attitude, environment, peers, and gender stereotypes. Teachers perceived boys as more talented and brighter than girls in Mathematics and logical thinking, and believe that boys tend to get better in Mathematics because of the higher expectations of them from both parents and teachers.

Overall, it seems that teachers tend to believe that boys are by nature able to succeed and if they do not do so it is because they have not tried enough. Girls, on the other hand, are successful at school not because they are smart but because they are diligent. Unfortunately, teacher beliefs about their male and female students' abilities may lead students to endorse gender stereotypes themselves. A study regarding middle-school students and teachers in Switzerland revealed that students of math teachers who stereotyped math as a male domain attributing innate ability to males, also tended to express similar stereotypes themselves (Keller, 2001).

Teachers' beliefs about gender differences: student learning styles. The same study (Chionidou-Moskofoglou & Chatzivasiliadou-Lekka, 2008) indicated that the majority of the teachers believe that girls learn differently than boys. They believe that girls need more explanations than boys because girls feel insecure to ask questions when they do not understand something. This reluctance in asking questions may derive from the case that girls are either embarrassed or afraid that their peers would make fun of them. In addition, most teachers believe that it is mostly female students who tend to abandon their tasks in Mathematics when they encounter difficulties. STEM teachers seem to associate girls with guided, and boys with independent learning (de Kraker-Pauw et al., 2016). In that sense, STEM teachers may differentiate teaching behaviors towards girls and boys in the classroom. This gender-biased approach may undermine girls' interest in STEM filed and subsequently their future participation in STEM education (de Kraker-Pauw et al., 2016).

3.4.1.3 Teachers' gendered classroom practices. Research shows that teacher differential conceptions of their female and male students' abilities are translated into gendered classroom practices (Garrahy, 2001, 2003; Li, 1999; Tsouroufli, 2002). Studies across a range of settings, have shown that teacher–student interaction is influenced by student gender (Jones & Dindia, 2004). Teachers tend to favor male students even when they think that their behavior is gender neutral (Garrahy, 2001). They tend to interact more with boys than with girls (She, 2000; Tsouroufli, 2002), to allow boys to participate more in classroom discussions (She, 2000), and to provide more academic feedback to boys (Duffy et al., 2001).

Li's (1999), review regarding the interaction in the mathematic classroom has arrived at a typical pattern: teacher-male student interactions are more frequent than teacher-female student interactions. Additional research in STEM education since then enhance that conclusion.

She (2000) performed a cross-relationship study on a Taiwanese seventh-grade biology teacher's beliefs, decisions, classroom practices and interaction with either male or female students. The study revealed that the teacher's classroom practice reflected her teaching beliefs. Specific characteristics attributed to boys and girls played an important role in establishing and maintaining differences in interactions between boys or girls and their teacher. The teacher's beliefs regarding male and female differences in learning style and classroom participation were reinforced or sustained by their behavior: unequal distribution of direct questions, unbalanced feedback and encouragement.

Garrahy (2001, 2003) conducted two studies concerning mathematics teachers' instructional practices with respect to their gender-related beliefs in the United States. In her studies, Garrahy employed multiple data sources (teacher interviews, classroom observations, classroom material analysis). The first case study, in 2001, had three participants, while the second in 2003, had two participants. Both studies concluded that even though teachers believed that they did not take students' gender into account when teaching, their classroom practices were not consistent with their expressed beliefs. Teachers' classroom practice demonstrated some stereotypical attitudes toward male and female students.

Ghosh's (2004) study showed that teachers believe that mathematics is more difficult for medial and low achieving girls than equally achieving boys. The researcher emphasized that while the gender differences in the upper level courses do not show any consistent pattern, gender differences in the lower level classes had a consistent pattern. In those courses boys had more interactions with the teachers than the girls had. According to the researcher, the female students' interaction rate with the teacher in the upper level courses are higher than the female students' interaction rate with the teacher in the lower level courses is possibly due to the high level of confidence in the students in the higher level courses. This study also revealed that, mostly, teachers' stated beliefs regarding gender and teaching and learning of mathematics and classroom interactions and practices were consistent.

The gendered interactions between teacher-student were the subject of the study of Jones and Dindia (2004). Researchers in their meta-analysis study examine patterns of gender differences in teacher-initiated teacher–student interactions found that that teachers initiate more overall and negative interactions, but less positive interactions, with male students than with female students.

Research in Greece has also revealed that teachers in mathematics classes tend to address more questions to boys rather than girls, offering the opportunity to boys to give more answers and, inevitably, receive more credit than girls (Chionidou, 1996) confirming the existing opinion that teachers' own gender stereotypes tend to condition their behavior in the classrooms (Chionidou-Moskofoglou & Chatzivasiliadou-Lekka, 2008)

A recent study regarding 107 teachers and student teachers from eleven secondary schools and three schools for higher education in Netherlands revealed that STEM teachers seemed to hold low expectations for their female students, following a more authoritarian interaction style (de Kraker-Pauw et al., 2016). Based on their biases about their students, STEM teachers might judge them based on their stereotypical beliefs and put girls on disadvantage (de Kraker-Pauw et al., 2016). In fact, it has been reported that females' performance may be affected to a greater extent by teachers' low expectations in comparison with males (Watson et al., 2016).

Teachers' awareness. Several studies have investigated whether teachers are aware of the gender stereotyped beliefs. Ifegbesan (2010) studies 250 practicing secondary school teachers' beliefs in Nigeria and reported that teachers are unaware and deny that they hold or perpetuate biased perceptions of males and females. A similar study in Israel investigating the attitudes and perceptions of teacher's behaviors' regarding student's gender role, revealed a relative lack of teacher awareness concerning the in-depth nature of gender stereotypes and their overall influences (Tatar & Emmanuel, 2001). Nevertheless, in some cases university teachers are largely aware of the gender stereotyped beliefs, and deny that they embrace or publicize biased perceptions of males and females (Gul et al., 2012). Actually, Gul et al. (2012) analyzed 155 university teachers' self-report questionnaire concerning perceptions of their classroom behaviors' to determine any differences between teacher perceptions of gender roles and perceptions of their behaviors' regarding their students' gender. They concluded that teachers have positive attitude towards male and female students, as they show no biased behavior towards student's gender. They exercise equitable attitude with students and encourage both regardless of gender. Most of the teachers detained gender-stereotypes and are embarrassed of gender-stereotypical practices in universities.

3.4.1.4 Observation tools for gender equity. Over time several tools have been developed to examine and analyze the teacher-student interactions in the area of gender equity. Griffin (1980) formed a '*Sex Role Dependent/Independent Teacher Behavior Observation System (SRDITBOS)'* to examine gender equity in physical education, while Sadker, Sadker, Bauchner, and Hardekopf (1984) developed the '*Interactions for Sex Equity in Classroom Teaching* (*INTERSECT) Observation System*' to code, analyze and evaluate class interactions. The *'Gender equity observation form (GEOF)'* created by Tracy and Lane (1999) was used to increase levels of awareness of preservice teachers helping them reflect on their own practice, foster improved teaching and learning, and implement gender-equitable teaching behaviors, while another tool concerning gender equality issues was employed during class observation of elementary and junior high school in Korea (Jung & Chung, 2005). The *toolkit for assessing and promoting equity in the classroom* developed within the *'Equity in the Classroom (EIC)'* project, presented a '*classroom observation instrument (COI)'*[15], consisted of a classroom mapping tool, indicating the physical location of the teacher and the students and an interaction tool for recording teacher-student interactions and whether equitable levels of attention, participation, and encouragement are being given to girls and boys. The Teacher's Handbook on Gender Responsive Pedagogy (Mlama et al., 2005) also presented a practical guide for making teaching and learning processes gender responsive. In an attempt to equip teachers with knowledge, skills and attitudes for gender responsive pedagogy, it demonstrated the significance of a gender responsive classroom set up, and highlighted many dynamics in the classroom interactions that have an impact on teaching and learning processes that are doubly important in considerations of gender responsive classroom interactions. The '*Classroom Observation Instrument (COI)*' proposed can be used to determine whether all students receive the same kind of questioning, wait time and feedback from their teachers. Recently, an *'Observing for Equity (OFE)'* tool, published by Teaching Tolerance[16], has emphasized on teacher's feedback to girls and boys and pointed out the need for recording the classroom set-up and dynamics during the class observations, while the '*observation device for charting interactions (ODCI)'*

15 https://www.unicef.org/lifeskills/files/AssessingEquity-EIC_Toolkit.pdf
16 http://www.tolerance.org/sites/default/files/general/Observing%20Equity.pdf

was designed to collect data from the verbal interactions between teacher and students, focusing not only on the questioning level but also on the verbal feedback provided by the teacher. Another tool, the *Observation Protocol for Gender Equity in Classroom (OPGEC)* tool developed by Morales and Espinosa (2014) also placed emphasis on teacher - student interactions and in some cases it was utilized to reveal gender-bias in the different aspects of teaching and learning in science and mathematics classrooms, such as classroom environment, teaching and learning processes, instruction, and assessment (Morales et al., 2016).

3.4.2 Teachers' Beliefs and Practices regarding Gender and Computing

The majority of the studies on teachers' gender-related beliefs regarding Computing provide insights mainly in the context of school ICT use. Information and Communication Technologies as digital literacy focus on the creative and productive use of technology, the application of computational tools to solve problems, and teaches how to be a thoughtful user of those tools.

Teachers from a range of disciplines who use computer and technology in class espouse stereotypical beliefs about males' and females' skills and ability in Computing, academic/career success in ICT-related fields (see section 3.4.2.1), and may reinforce these views with their teaching practices (see section 3.4.2.2). Yet, there is not systematic, consistent research evidence on CS teachers' gendered beliefs and practices and the impact on students' beliefs, behaviors, and achievements.

3.4.2.1 Teachers' gender-related beliefs. The belief that studies in CS are not suitable for girls and that girls are not able in Computing is based on a narrow view about: (a) the *skills, abilities*, and *personal traits* that are needed to be successful in a Computing field (De Castell & Bryson, 1998; Sáinz, Pálmen, & García-Cuesta, 2012; Singh, 1993; Vekiri, 2013b), and (b) the range of potential CS careers (Sáinz et al., 2012).

Skills, Abilities and Personal Traits. An early study on instructional computer use conducted in a fifth-grade classroom in Australia reported that the classroom teacher described the boys as more assertive, willing to take risks and competent than girls (Singh, 1993). A qualitative study of primary school teachers, computer coordinators and principals, carried in Canada showed that participants either denied the gender gap in Computing or tended to explain it with stereotypes, by attributing it to natural differences in the interests and abilities of males and females (De Castell & Bryson, 1998). Personal traits were, also, employed to explain the gender gap in CS in an ethnographic study of learning environments at postsecondary CS courses, where Garvin-Doxas and Barker (2004) observed that many teachers referred to good programmers as people who were *smart* attributing this characteristic to males. A recent research in Spain, through interviews, examined the views of secondary teachers about the gender gap in Computing and their own influence in their students' career choices. This study revealed that many teachers explained the gender gap by referring to gender differences in interests and personality traits, and most of them did not recognize their own responsibility in shaping their students' interests and academic decisions (Sáinz et al., 2012).

A more recent study in Greece investigated whether primary teachers espouse common stereotypical views about the abilities and personality characteristics of boys and girls relative to ICTs and about the suitability of CS as possible future domains of study for girls (Vekiri, 2013b). The researcher, also, explored the relationship of teachers' gender-stereotyped views with teachers' gender, age, computer experience and self-efficacy in educational computer use. The participants, 241 Greek primary teachers (85 male and 156 female), answered a structured questionnaire. All of them recognized that developing ICT skills was equally important for all students, many of them tended to agree with prevailing stereotypes about boys' and girls' relationship with technology, and more than one-third of them thought that boys were more likely to have the *aptitude*, *interest* and *personality characteristics* to pursue studies in CS, associating student interests with *abilities* and *personality traits*. Interestingly, female teachers who were quite competent and efficacious ICT users were equally likely to express stereotyped views with male or with less efficacious female teachers.

It seems that teachers perceive gender differences as *natural*. In that sense, for them, the gender gap in the ICT fields or any gender imbalances in their students' uses of ICTs is not problematic, thinking that they cannot influence positively their students' interests and abilities (Sáinz et al., 2012). The '*no problem'* theme has been highlighted by Sanders (2005) who reported that teachers did not recognize the gender gap because they do not make the distinction between using technology and creating computational tools. Teachers were pleased to see girls' participation in low levels of ICT without noticing their limited participation in advanced CS courses.

The range of potential CS Careers. Teachers who hold inaccurate images about the nature of Computing fields and professions may think that studying Computing is not appropriate for girls and/or that girls have less potential to succeed in Computing (Sáinz et al., 2012).

Keeping in mind the result of these studies, any intervention, in order to promote gender equity, have to dispute the belief that abilities and interests are *fixed entities*, challenging the stereotype that Computing is incompatible with female students' interests, abilities, and personal traits. It is also necessary to increase teacher awareness of the nature and range of Computing professions.

3.4.2.2 Gender-related teachers' beliefs and practices. Research evidence in the context of school ICT use (Singh, 1993) indicates that stereotyped beliefs influence teacher practices, communicating gendered expectations, visible to the students, possible favoring boys, even unintentionally.

In the study of De Castell and Bryson (1998) some of the computer coordinators reported that they deliberately adjusted their pedagogical practices in the computer lab depending on the gender composition of the student body, such as providing more technical information and explanations in a class of boys. A later study, involving observations in 30 primary classrooms in England, revealed that after one year of interactive whiteboard use in the classroom the gender imbalance in teacher-student interaction widened, as communicated more with boys (Smith, Hardman, & Higgins, 2007).

Perceived teachers' behavior. From the perspective of value-expectancy theory students' motivation as well as academic and career choices are influenced by their beliefs about the *expectancy* (*competence* and *confidence)* of success in tasks of certain domain and by the *value* (*attainment, utility, intrinsic*) they attribute to a particular domain (Eccles, 2007; Wigfield & Eccles, 2000). Positive experiences that enable individuals to succeed tend to enhance expectancy and value beliefs. However, these beliefs are also influenced by their perceptions of the subject and by other people's expectations and views. Stereotypes about gender ability differences in certain academic fields or about the traits of these fields and their suitability for males and females, communicated from important socializers, can influence students' interpretations of their learning experiences. In that sense, as important socializers and sources of authority and expertise, teachers are likely to exert a powerful influence on students' expectancy and value beliefs by *providing* learning opportunities and *encouraging* students' engagement in Computing activities, *communicating positive achievement expectations* and stress the usefulness, importance and appropriateness of Computing (Alkhadrawi, 2015; Gürer & Camp, 2001). Teachers can enhance student motivation for learning using interesting, challenging and authentic tasks that provide opportunities for exploration and collaboration and are connected to the real-world (Gürer & Camp, 2001). The influence of teacher behaviors and expectations on boys' and girls' ability beliefs is also highlighted in Bandura's social cognitive theory (Bussey & Bandura, 1999). According to that theory, students' perception of competence, is enhanced when learners experience success and perceive high expectations for their performance from significant others.

Several studies investigated how students perceive their teachers behaviors, realize their expectation, and interpret their learning experiences regarding gender difference and ICT (Shashaani, 1993; Singh, 1993; Vekiri, 2010, 2013b)

Singh's (1993) interviews with primary school students showed that girls perceived discrimination in their teacher's behavior, believing that their teacher underestimated their computer knowledge and assigned less challenging tasks to them compared with the boys. Another early study conducted with high school students in the US, found that both male and female students perceived that their CS teachers to have stereotyped views about the appropriateness of CS for females (Shashaani, 1993).

Two studies in Greece provided useful insights about the role of perceived teachers' expectation and pedagogy on boys' and girls' ability beliefs, achievements, expectancy, and value beliefs of Computing (Vekiri, 2010, 2013a). Vekiri (2010) explored two teacher factors; *teacher expectations* and *pedagogy*, and their relationship to students' value and efficacy beliefs. The participants of her study were 301 (135 male and 166 female) students who responded to a self-report questionnaire. The results showed that perceived teacher expectations were positively associated with students' ability beliefs (beliefs about their computer competence), while student perceptions of learning activities as creative and personally meaningful was a significant predictor of value beliefs. This study showed that perceived teacher expectations was more significant for girls' than it was for boys' efficacy, while a positive perception about the instruction were associated with positive beliefs about the value of ICTs in boys, and it was only associated with interest (intrinsic value belief) in ICTs in girls. Thus, despite the fact that student-centered approaches to Computing is motivating for both boys and girls, such teaching approaches may have a positive impact on girls' *enjoyment* and *interest* in computers but may not affect their perceptions of the *importance* and *usefulness* of Computing, which are related to student long-term plans and personal values (Eccles, 1994).

In a later study, Vekiri (2013a) using student self-reports examined the effects of pedagogical practices on changes in boys' and girls' *expectancy* and *value beliefs* about Computing. The participants were 326 7th-grade students, enrolled in three middle schools In Greece. The results revealed that boys expressed more positive intrinsic-value beliefs about Computing. Teachers' pedagogical practices had effects on students' motivation. All students benefited from practices that highlighted the social benefits and applications of technology. Also, girls benefited from practices that connected Computing to other school subjects and boys from practices encouraging social interaction.

Finally, the gender of the teacher may affect the ICT use in class. In some studies female teachers appear less confident and less likely to use computers in the classroom compared with their male colleagues (Meelissen & Drent, 2008). This lack of confidence about their own abilities regarding ICTs may endorse cultural stereotypes about females and Computing.

3.5 Challenging Beliefs

3.5.1 Beliefs Resist Change

One common argument in the literature about teachers' beliefs is that changing them is a complex, even a mysterious, process (Mansour, 2009). Beliefs vary in strength

(Rockeach, 1986), are static (Nespor, 1987), resistant to change (Brousseau, Book, & Byers, 1988), and constantly develop over time into a form of system or network which then becomes resistant to change (Rockeach, 1968).

Beliefs vary in strength and kind; the ease with which teachers can change their beliefs is related to the strength of the particular beliefs under scrutiny (Ertmer, 2005). Beliefs are held in clusters, organized in systems along a dimension of centrality to the individual. The more central a belief is, the more difficult is to change. In that sense, stronger beliefs are those that are more central to an individual's identify, quite possibly because they were established during earlier experiences and, thus, were used in the processing of subsequent experiences (Pajares, 1992).

The separation of clusters of beliefs may be such that it is possible for a person simultaneously to hold conflicting beliefs: "*Clusters of beliefs around a particular object or situation form attitudes that become action agendas*" (Pajares, 1992, p. 319). Only when circumstances bring both clusters of belief into play does the dissonance become apparent and require resolution.

Beliefs' functioning contribute to their resistance to change. Actually, beliefs provide personal meaning and assist in defining relevance, helping individuals to identify with one another and form groups and social systems. From both a personal and socio-cultural perspective, belief systems reduce dissonance and confusion. Thus, they acquire emotional dimensions and resist change. People grow comfortable with their beliefs, and these beliefs become their "self" so that individuals come to be identified and understood by the very nature of the beliefs and habits they own. (Pajares, 1992, p. 317).

Griffin and Ohlsson (2001) described belief revision as being highly subject to *motivational influence* and *epistemological values*. Participants in their study indicated that, even if presented with sound conflicting evidence, they would not be willing to change their affect- based beliefs (e.g., belief in an afterlife; disbelief in evolution), but were relatively willing to change their knowledge-based beliefs (e.g., belief in evolution; disbelief in an afterlife).

Based on Rokeach's (1968) scheme, it may be that affect-based beliefs, because they are more intimately connected to our personal identities, reside in a more central position in our belief systems, while knowledge-based beliefs, because they are less personal, exist somewhere on the periphery.

3.5.2 Perspectives on Beliefs' Change

Although beliefs are not readily changed, this does not mean that they *never* change (Nespor, 1987; Pajares, 1992). According to Nespor (1987), beliefs change, not through argument or reason, but rather through "*a conversion process or Gestalt shift*" (p. 321).

Piaget's concepts of *assimilation* and *accommodation* can be applied to the description of how new phenomena are dealt with and lead eventually to understanding how beliefs change (Pajares, 1992; Mansour, 2009). "*Assimilation is the process whereby new information is incorporated into existing beliefs in the ecology; accommodation takes place when new information is such that it cannot be assimilated and existing beliefs must be replaced or reorganized*" (Pajares, 1992, p.320). Thus, minor changes in beliefs can be assimilated into the existing belief system; major changes in beliefs require accommodation (Mansour, 2009). Both result in belief change, but accommodation requires a more radical alteration (Pajares, 1992).

When beliefs are deep an individual is more likely to assimilate new information rather to accommodate it. Teachers, and specifically pre-service teachers, often assimilate new ideas that fit their existing schemata instead of accommodating their existing schemata to internalize new ideas (Thompson, 1992).

To accomplish accommodation, individuals must *be dissatisfied with their existing beliefs* (Ertmer, 2005) and new beliefs must be understandable and appear plausible (Pajares, 1992). This is most likely to happen when either existing beliefs are *challenged* or new beliefs cannot be assimilated into existing ideas (Ertmer, 2005). Nevertheless, new beliefs must *be consistent with* and have *conceptual connections to* other beliefs in the belief system. Actually, prior beliefs organize and define new information.

Kagan (1992) noted that if a teacher education program is to be successful at advocating belief change among teachers, *"it must require them to make their preexisting personal beliefs explicit; it must challenge the adequacy of those beliefs; and it must give* *novices extended opportunities to examine, elaborate, and integrate new information into their existing belief systems"* (p. 77).

In order to change, or shape, teachers' beliefs, objective data on the adequacy or validity of their beliefs have to be presented to them (Nespor, 1987). Of course, this can result in transformations of teachers' beliefs, and practices, only if alternative or new beliefs are available to replace the old. Teachers, and prospective teachers, have to be *reflexive* and *self-conscious* of their own beliefs (Pajares, 1998)

3.6 Eliciting Beliefs

The investigations of teachers' beliefs is a necessary and valuable avenue of educational inquiry (Pajares, 1992). Regarding CS along with several aspects of teachers' beliefs, this avenue continues to remain lightly travelled. Researchers, who followed this path, were rewarded and found relationships between teachers' beliefs and their planning, instructional decisions, and classroom practices. Due to the different definitions of the term *beliefs* and the non-recognition of the interactions among beliefs sub-constructs or their connection to other cognitive of affective structures, it has been difficult to clearly understand the relationships (Pajares, 1992).

Understanding teachers' beliefs will help us to realize how teachers view their work, how teachers' beliefs affect their behavior in the classroom, how teachers use new information about teaching and learning in their teaching practices, how teaching practices and professional teacher preparation programs can be improved (Pajares, 1992, Borg, 2001, Nespor, 1987).

Apart from the definitional problems, one of the difficulties in investigating teachers' beliefs concerns the access to teachers' beliefs and thought processes. Rokeach (1968) stated that beliefs could neither be measured nor observed. Donaghue (2003) explains why beliefs and thought processes cannot be directly accessed. Firstly, teachers' beliefs may be held subconsciously and so teachers may be unable to explain what they have on their minds or what goes on in their minds. Secondly, teachers– subconsciously or consciously– may want to project a particular image of themselves, especially if they are being evaluated or taking part in a research study or project.

The methodology and the design of studies, as well as the measurement of teachers beliefs, need careful consideration. The connections and the centrality of beliefs is essential to understanding the nature of their effect, thus, researchers have to study the context-specific effects of beliefs in terms of these connections. "*Seeing educational beliefs as detached from and unconnected to a broader belief system is ill advised and probably unproductive*"(Pajares, 1992, p. 326). It is crucial to think in terms of connection among beliefs instead of beliefs as independent subsystems.

It is clear that if reasonable conclusions on beliefs require assessments of what individuals *say, intend,* and *do,* then teachers' *verbal expressions*, *predispositions to action*, and *teaching behaviors* must all be included in assessments of beliefs (Pajares, 1992). Not to do so put in doubt the validity of findings and the value of the study.

Traditional belief inventories, which present teachers a list of beliefs and ask them to respond that list, provide limited information in order to make inferences. The understanding of the context-specific nature of beliefs is crucial. Additional measures such as *open-ended interviews*, responses to *dilemmas,* and *observation* of behavior must be included in order to reach accurate inferences (Pajares, 1992).

The predominant approach used by researchers to measure beliefs is to employ qualitative measures, including teacher interviews, classroom observations, responses to simulated materials, concept generation and mapping (Philipp, 2007). The qualitative research methodology is relevant, appropriate, and promising in order to arise rich and accurate inferences (Pajares, 1992). Although *quantitative* methods typically have been used in studying efficacy beliefs, qualitative methods, such as case studies or oral histories, are needed to gain additional insights (Schunk, 1991). Qualitative approaches allow researchers to gain a more in-depth and hermeneutic explanation and understanding of teachers' beliefs and thinking processes. Although qualitative approaches provide rich data sets, they are expensive to employ across large numbers of participants. Researchers who need to collect large data sets often rely upon less expensive approaches, such as Likert-scale surveys (Philipp, 2007).

Education researchers have approached the study of teachers' beliefs in one of two ways: by using *case-study methodology* or by using beliefs-assessment *tools*. Perhaps the more common approach has been to use *case-study methodology* to provide detailed descriptions of the beliefs of a small number of teachers by relying upon rich data sets that include some combination of classroom observations, interviews, surveys, stimulated recall interviews, concept mapping, responses to vignettes or videotapes, and linguistic analyses (Philipp, 2007). These data are often collected over a period of time and triangulated. These rich data sets are important for theory building, as they enable researchers to consider interrelationships in the complex world of teachers (Philipp, 2007). Such studies also enable researchers to meet the challenge to investigate the dialectic relationship between teachers' conceptions, including their beliefs and knowledge, and teachers' practices (Pajares, 1992; Thompson, 1992).

Section B. Research: Problem State and Research Methodology

Chapter 4.

Problem State and Research Methodology

Summary: This chapter states thoroughly the research problem and set the threefold objective of this thesis along with the research questions that are to be answered. The three individual studies designed and implemented, each to serve one aim of the thesis, are also introduced and the research methodology, constructed on the basis of the theoretical concept of *"The Research Onion"*, is fully described.

The literature review provided a critical overview of the research in the fields of gender and Computing as well as teachers' gender-related beliefs and practices. As it is shown in the theoretical background (see chapter 2), gender gap in CS education is well documented in a number of countries. However, in Greece, systematic research for the gender representation in CS education has not been carried out till now. More specifically, in Greece, Computing has been established in the curriculum in secondary education for more than two decades while CS University depts have been instituted in Greek Tertiary education for more than three decades. Along with the emerging Information Age at the beginning of the 21st century, Computing has become a promising field of study with great career prospects for many male and female students in Greece. Taking the above into consideration, it is worthwhile to examine systematically, for a period of time, the gender representation in CS education in Greece so as to justify the existence or the absence of the gender gap as well as its extent.

In addition, the need to fill the gender gap in Computing is well documented in the literature, whereas several studies have identified several key and structural factors affecting females' participation in CS, deterring them from entering the field (see Chapter 2). It seems that girls face negative stereotypes about their abilities that contribute to their loss of interest and confidence in CS. These negative stereotypes are based on some socially constructed 'myths' about gender differences in cognitive skills and academic ability, yet, evidence from related STEM fields supports that actual gender differences in cognitive skills and academic ability are non-existent (see chapter 2). Nevertheless, despite the fact that no significant differences in the performance of males and females in STEM have been reported, course selections within disciplines of STEM reveal certain persistent differences in preferences. Regarding Computing, there are some indicators that students' performance is not differentiated because of gender but is actually related to their self-competence, their self-efficacy beliefs and motivation. Yet, the above mentioned 'myths' about females' abilities and performance in CS have not been fully challenged and the gendered preferences within CS have not been studied till now. Thus, it is worthwhile to investigate gender differences in performance and preferences in CS in order to dispel or accept gender myths about females' abilities and simultaneously uncover possible gender preferences in specific domains of Computing.

Another crucial factor affecting females' engagement in CS seems to be school education, and especially Computing teachers' practices in class. In Computing and STEM fields, teachers' beliefs and their impact on their decisions in the educational setting as well as their actual classroom practices have been studied to a certain degree (see chapter 3). Nevertheless, teachers' gender-related beliefs about girls' and boys' abilities and learning behavior have been examined mainly in STEM fields verifying that those fields are particularly likely to evoke associations with gender. Research results in STEM fields (presented in chapter 3) suggest that teachers' gender-related beliefs may sustain existing, possibly undesirable, situations with regard to the expectations from girls and boys which influence their interest, performance and confidence accordingly. Yet, despite the significant role of the Computing teachers' beliefs and practices in perpetuating negative stereotypes that may affect females' confidence, performance and interest in CS, their gender-related beliefs and practices have not been yet investigated. In that sense, it is worth studying Computing teachers' gender-related beliefs and their relations, if any, with their actual teaching practices in class.

Recapitalizing, the objective of this thesis is mainly threefold: (a) aim 1-to examine the gender representation in Greek Computing education, (b) aim 2-to investigate gender differences in preferences and performance in the undergraduate CS courses, and (c) aim 3-to study Computing Teachers' gender-related beliefs and practices by exploring what teachers say and what they do in class.

This threefold objective is further analyzed in more detailed sub-aims and research questions in the following sections.

4.1 Aim 1: Gender Representation in Greek Computing Education

To draw a clear picture of gender representation in Computing education in Greece, it is essential to investigate gender representation in secondary education in terms of Computing teachers (sub-aim 1.1), and in tertiary education, in terms of students/graduates (sub-aim 1.2) and faculty members (sub-aim 1.3). The investigation of gender representation for a considerable amount of time -for a decade- would uncover trends throughout the years. A cross-sectional analysis with the gender representation in related disciplines included in STEM education during the same period would also reveal possible dynamics and uncover the extent of the problem of the female under-representation in Computing compared to other STEM fields. The selected decade to study the gender representation in Greek Computing and STEM education was the years from 2003 to 2012 for two main reasons: (a) Computing has been established in the Greek secondary level of education curricula at the beginning of the 21st century and CS has become a promising field of study with great career prospects for many students (b) the data collected were the most up-to-date available data at the time of data collection.

4.1.1 Sub-aim 1.1: Teacher Gender Representation in Greek Computing Secondary Education

As it is shown in the literature review (see chapter 2), one of the most important factors influencing females' decisions to pursue Computing is role models. Unfortunately, most of the images from females' social environment form a Computing stereotype in which males, more than females, are presented using computers for hours, lacking other social interests, therefore, implying that Computing is really for males only. It has been pointed out that most young females have rarely been exposed to a Computing class with a Computing scientist female role model (Townsend, 2002; Liston et al., 2008; Cheryan & Plaut, 2010). Yet, it has been reported that teachers 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 (Lunenberg et al., 2007). Additionally, when it comes to career prospects, if young females think about CS as a career choice, the presence of a successful female in Computing appears to be an encouraging signal. Consequently, it makes sense that a certain level of comfort may be achieved between a young female student and an accomplished female teacher; however, if this is so, and female Computing teachers could become ideal female student mentors who could recruit females in Computing, this begs the question: Are there enough of them?

Bearing this in mind, sub-aim 1.1 of this thesis is to examine systematically the gender representation of Computing teachers in secondary education in Greece during the decade 2003-2012 and compare it to the female representation in related disciplines in

STEM education during the same period. The female representation in both cycles of study of secondary education (Gymnasium and General Lyceum/Vocational Lyceum) in Computing and the trends during the decade under study would reveal whether female teachers could arouse girls' feeling they fit in Computing which is critical for girls' recruitment. Moreover, the comparison of female Computing teachers' representation with the female representation in the related STEM disciplines would indicate whether female Computing teachers are better or worse represented compared to those female teachers in the STEM disciplines illustrating the extent of the possible gap.

Sub-aim 1.1 brings us the following two research questions:

RQ1.1.i. What is the schoolteacher gender representation in Computing and related STEM disciplines in secondary education during a whole decade (2003–2012) in Greece ?

RQ1.1.ii. What is the comparison between the female Computing teachers representation with the female teachers representation in related discipline in STEM secondary education during the decade 2003–2012 in Greece?

4.1.2 Sub-aim 1.2: Student and Graduate Gender Representation in Greek Computing Tertiary Education

As it has already been mentioned, since the turning point in the late 1980's, the proportion of women studying CS fell dramatically and continued in a consistent descending trend. Nonetheless, the bigger picture of the representation of women in CS drawn on longitudinal studies in several countries revealed that there are several dynamics at the undergraduate level compared to the graduate level, suggesting that even though females' participation at the graduate level (master's and doctoral degrees) is still low, there is a slight increase across the decades. It is at the undergraduate level in which the proportion of women earning CS degrees constantly declines.

Within this context, sub-aim 1.2 of this thesis is to systematically investigate during the decade 2003-2012 the gender representation in Computing and STEM at Tertiary level of education in Greece in terms of undergraduate (freshmen, graduates) and graduate studies (master's degree graduates and PhD's) so as to uncover trends throughout the years, confirm or reject the dynamics at the graduate level appeared in related studies in other countries, and reveal whether recruitment or retention in Computing is the actual problem for females. The comparison with relevant disciplines in the STEM education for the same level of studies and during the same decade would clarify how females are represented in Computing compared to the rest STEM fields.

To accomplish sub-aim 1.2, the following two research questions were posed:

RQ1.2.i. What is the student gender representation in Computing and related STEM disciplines in tertiary education during a whole decade (2003-2012) in Greece, in terms of undergraduate (freshmen, graduates) and graduate studies (master's degree graduates and PhD's)?

RQ1.2.ii. What is the comparison between the female student representation in Computing with the female student representation in related disciplines in STEM tertiary education during a whole decade (2003-2012) in Greece, in terms of freshmen, graduates, master degree graduates and PhDs?

4.1.3 Sub-aim 1.3: Faculty Member Gender Representation in Greek Computing Tertiary Education

Apart from recruiting females in CS, their retention in the field seems to be of equal importance. As it has been highlighted in the literature review (see Chapter 2), the existence of female faculty members in Computing depts can play a crucial role in female-student retention in the field as they demonstrate the presence, the participation, and the continuing prospects of women in CS. During undergraduate and graduate studies, both male and female students interact and cooperate with their professors. These interactions are of importance from every aspect, building students' capacity as scholars, fostering degree aspiration and retention, and promoting the students' success in under-represented backgrounds, such as females in Computing and STEM (Baker & Griffin, 2010). Several studies credit faculty – student interactions with improving students' development as thinkers and scholars, confidence in their own abilities, integration into university communities, and interest in graduate education (Johnson, Rose, & Schlosser, 2007). In a true interaction between a female student and an accomplished female professor; both the mentor and the mentee are free to "let their guard down" and speak freely of their concerns, aspirations, and fears (Camp, 2002). The undoubtedly positive role of a female role model in the retention of females in Computing and STEM highlights the need to investigate the presence of the female faculty who could act as mentors/role models in such depts.

To that end, it is worth examining gender faculty-member representation in Computing during a decade in Greece and comparing it to the gender faculty-member representation in the remaining fields of STEM education. This forms sub-aim 1.3 of the present thesis and it is approached by making an attempt to answer the following research questions:

RQ1.3.i. What is the faculty gender representation in Computing and related STEM disciplines in tertiary education during a whole decade (2003-12) in Greece, in terms of professors, associate professors, assistant professors and lecturers?

RQ1.3.ii. What is the comparison between the female faculty representation in Computing with the female faculty representation in related disciplines in STEM tertiary education during a whole decade (2003-12) in Greece, in terms of professors, associate professors, assistant professors and lecturers?

4.2 Aim 2: Gender Differences in Performance and Preferences in Computing Education

As it was mentioned in the literature review (see chapter 2), females face negative stereotypes about their abilities in Computing, making them feel like they do not fit well in the field. These negative stereotypes, based on some socially constructed ‘myths’ about gender differences in cognitive skills and academic ability, could affect their self-efficacy beliefs and consequently their actual performance in Computing. Even though there is not extensive research in Computing, there are some indicators that males and females perform equally well. Yet, research has divulged certain persistent differences in preferences regarding STEM disciplines.

Keeping the above in mind, it makes sense to investigate whether the gender gap in Computing could be attributed to differences in performance and if there are any gender differences in Computing course preferences. Despite the relevant research in related STEM fields, a study investigating gender differences within CS in terms of performance and course preferences in the entire curriculum of a CS dept has not been reported so far.

In that sense, the second aim (aim 2) of this thesis is to increase our understanding of gender differences in CS by exploring if there are gender differences related to the entire curriculum of a CS dept in terms of: (a) course preferences (sub-aim 2.1), and (b) performance (sub-aim 2.2). Thus, to approach this aim the following research questions are formulated:

RQ2.1.i What are the differences between males' and females' course preferences in a CS department?

RQ2.2.i What are the differences between males' and females' performance in courses included in a CS department's curriculum?

4.3 Aim 3: Computing Teachers' Gender-Related Beliefs and Practices

The literature review (Chapter 3) provided a thorough analysis of teachers' beliefs by underlying their influence on their practices which can have a significant impact upon the learning experiences provided for the students and affecting their behaviors accordingly. In STEM fields, teachers' gender-related beliefs is an issue of extensive research as it seems that teachers' beliefs about girls' and boys' abilities, characteristics and learning styles may affect students', especially girls', learning experiences and as a consequence their self-esteem, confidence, performance and interest. A wealth of studies has also revealed that STEM teachers seem to hold stronger implicit gender-related beliefs linking male gender to STEM abilities. These beliefs are translated into gendered classroom practices reinforcing stereotypes of gender differences in abilities and achievements.

Regarding Computing teachers, research has concentrated on their pedagogical beliefs (Fesakis & Karakiza, 2011), their beliefs both about teaching and learning (Carbone et al., 2007; Kordaki, 2013), their beliefs about teaching using digital technology (Lameras et al., 2012) as well as about the abilities students can obtain through Computing and their views about themselves (Romeike, 2010). Only a few of these beliefs were examined along with their actual practices in class (Kordaki, 2013). Most of the aforementioned studies provided insights in the beliefs of teachers from a range of disciplines in the context of school ICT use. Yet, there is not research evidence on Computing teachers' gendered beliefs and their relation (if any) to their practices. In fact, teachers' beliefs could have an impact on students' beliefs and achievements because students' expectancy and value beliefs, which are critical for their motivation as well as academic and career choices, are enhanced by positive school experiences and influenced by teachers' communicated beliefs and practices. In that sense, Computing teachers' gendered practices that may stem from stereotypes about gender ability differences in the Computing class are likely to influence females' expectancy and value beliefs and progressively affect their engagement in Computing.

In this context, the final aim of this thesis is to examine male and female Computing teachers' gender-related beliefs about their students in relation to Computing, Computing as a school subject and gender differences in a Computing class (sub-aim 3.1) as well as to investigate their real class practices regarding their interactions with girls/boys (sub-aim 3.2). Eventually, an attempt will be made to uncover possible associations between Computing teachers' expressed beliefs and their actual practices in class (sub-aim 3.3).

The latter issues have led to approach the third aim of this doctoral thesis by formulating the following research questions:

RQ3.1.i. What are Computing teachers' gender-related beliefs with regard to Computing, girls/boys and Computing as well as gender differences in Computing?

RQ3.2.i. What are the Computing teachers' practices with girls/boys in a Computing class in terms of verbal/non-verbal interactions?

RQ3.3.i. What is the relationship between Computing teachers' expressed gender-related beliefs and their actual practices in class with regard to student gender?

4.4 Research Methodology

In order to fulfill the threefold aim of this thesis and answer the research questions posed in the previous section, three individual studies, each for every aim, were designed: *'**Study1**: Gender Representation in Computing Education in Greece', '**Study2**: Gender Differences in Preferences and Performance in Computer Science Education', '**Study3**: Computing Teachers' Gender-Related Beliefs and Practices'.*

Figure *4* presents these three studies in accordance with the aims, sub-aims, and research questions of the thesis.

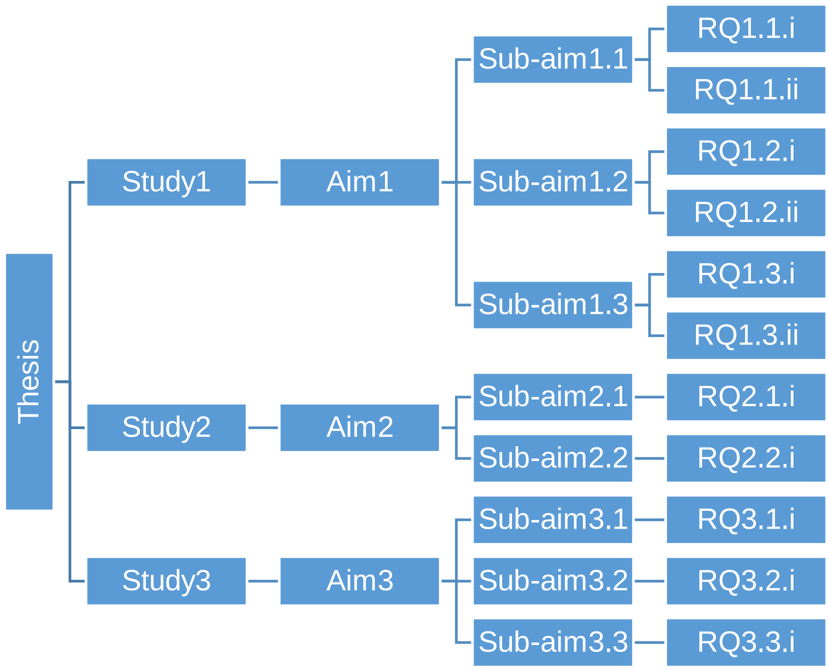
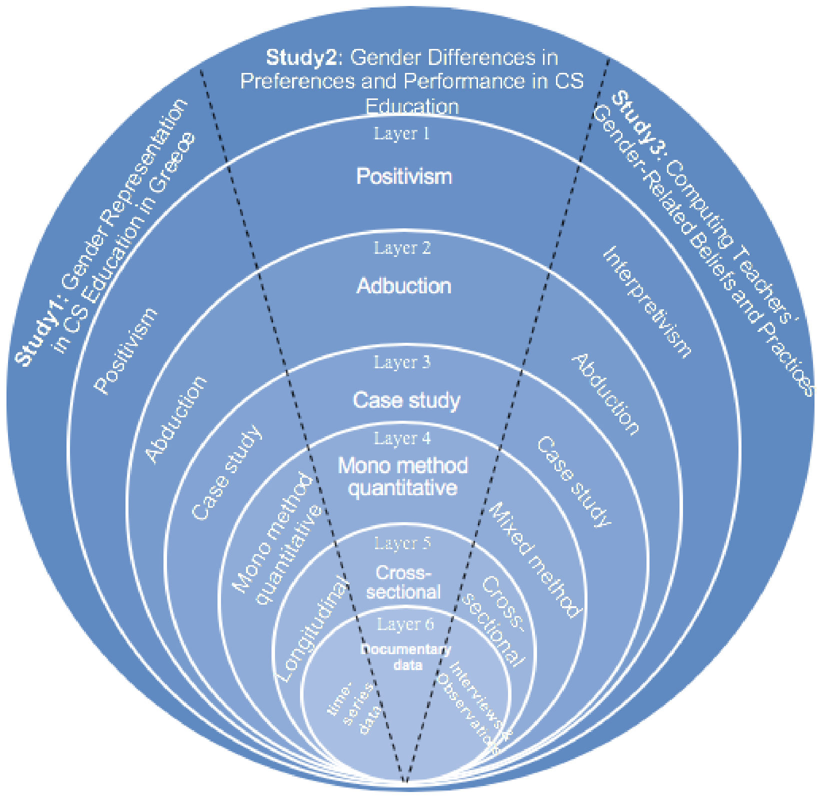


Figure 4. Studies in correspondence with the aims, sub-aims and research questions of the thesis

For each of these studies a research methodology was implemented based on the theoretical concept of *"The Research Onion"*, proposed by (Saunders et al., 2009; Saunders, Lewis, Thornhill, & Bristow, 2019), which provides a rather exhausting description of the main layers or stages which are to be accomplished in order to formulate an effective methodology. It encompasses all important components of the research process in the form of six layers: the first two layer (philosophies and approaches) comprise the *theory of science*; the third, fourth and fifth layer (strategies, methodological choices and time horizon respectively) formulate the *research design*; while the sixth and final layer entails the data collection and analysis techniques.

For each of the individual studies, *Study1*, *2* and *3*, the research strategy in terms of onion layers are depicted in Figure 1 that encloses the three adapted *'Research Onions'* for those three studies.



Layer 1: Philosophical stances	Layer 2: Approaches	Layer 3: Strategies	Layer 4: Choices	Layer 5: Time Horizon	Layer 6: Techniques and Procedures

Figure 5. Research methodology - Adapted from 'The Research Onion' by Saunders et al. (2019, p. 130)

4.4.1 Research Philosophies and Approach

4.4.1.1 Research philosophies. Research philosophy forms a basis of the research by delineation of *ontology* (nature of reality or being), *epistemology* (what constitutes acceptable, valid and legitimate knowledge), and *axiology* (values, beliefs and ethics of the research). From the five major philosophies proposed by Saunders et al. (2019), *'Positivism'* and *'Interpretivism'* are those two philosophies followed by the 3 individual studies of this thesis.

Positivism. Positivism relates to the philosophical stance of the natural scientist and entails working with an observable social reality. Positivism focus on "strictly scientific empiricist method designed to yield pure data and facts uninfluenced by human interpretation or bias" (Saunders et al. 2019, p. 144). *'Ontology'* is based on objectivist assumptions that entities are observed, existing external to social actors, therefore only observation and empirical data may be referred to as “credible”. Regarding *‘epistemology’*, the focus is upon discovering measurable facts and regularities and only phenomena that can be observed and measured to produce credible and meaningful data (Saunders et al. 2019). In relation to *‘axiology’,* in positivism the researchers is detached, neutral and independent of what is researched, maintaining an objective stance.

The research philosophy behind the research design of *Study1* and *Study2* is the philosophical paradigm of positivism. In particular:

Study1. This study is designed to use numerical data in order to present the reality of the gender representation in C+STEM education in Greece for a decade uninfluenced by human interpretation or bias. The data analysis will provide an objectivist approach of this reality, existing external to social actors.

Study2. This study is designed to employ pure numerical data from the official records of the DCS&T uninfluenced by human interpretation or bias. The focus is on scientific measurable facts while the statistical analysis (descriptive and inferential statistics), provide an objectivist approach of students’ preferences and performances in the courses included in the curriculum of the specific department.

Interpretivism. Interpretivism emphasizes that humans are different from physical phenomena because they create meanings. Interpretivists study those meanings. The purpose of interpretivist research is to create “new, richer understandings and interpretations of social worlds and contexts” (Saunders et al. 2019, p. 149). Interpretivism is an approach based on subjectivist *ontological* assumptions that entities are constituted of discourse, thus existing or socially constructed reality may be only researched through social constructions. Reality is socially constructed by the people who are living in it (Blaikie, 2009) and constantly evolving, therefore *knowledge and facts* are relative and subjective. Focusing on complexity, richness, multiple interpretations and meaning-making, interpretivism is explicitly *subjectivist*. An *axiological* implication of this is that interpretivists recognize that their interpretation of research materials and data, and thus their own values and beliefs, play an important role in the research process. Researcher is “*part of the research and the challenge is to enter the social world of the* *research participants and understand that world from their point of view*” (Saunders et al. 2019, p. 149).

For ‘*Study3: Computing Teachers’ Gender-Related Beliefs and Practices*’ an interpretivist paradigm has been adopted. For Study3 it is the meanings and interpretations of the teachers that have led to the construction of the reality described. Thus, the meanings, the interpretations and the reality constructed is subjective. For this study, the researcher is aware that the interpretations of the interview materials and his own beliefs/values may play a crucial role in the research process.

4.4.1.2 Research approach. Saunders et al. (2019) distinguish three main approaches to theory development – *deductive*, *inductive* and *abductive.* For the purpose of the three studies of this thesis *abductive* reasoning has been adopted. Instead of moving from theory to data (as in deduction) or from data to theory (as in induction), an *abductive* approach moves back and forth, in effect combining deduction and induction (Suddaby 2006). In abduction inference, known premises are used to generate testable conclusions. Data collections are used to “explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test them incorporating existing theory where appropriate, building new or modifying existing theory” (Saunders et al., 2019, p.153). According to (Paavola, Hakkarainen, & Sintonen, 2006) abductive inference is a best guess or conclusion based on available evidence.

The research approach adopted for *Study1*, *Study2* and *Study3* of this thesis is the *abductive* reasoning. In particular:

Study1: Gender representation in Computing education is an issue of excessive research in several countries and there is a wealth of research evidence about the female under–representation in the field. This study seeks to explore this phenomenon in Greek education, by identifying possible similar patterns, discussing and comparing the extend of the problem in C+STEM education, revealing dynamics, contributing to the existing research data by providing valuable information from the Greek case. The abductive reasoning seems therefore appropriate to be the research approach for *Study1*.

Study2: Gender differences in performance and preferences in C+STEM education is an issue of research for many researchers around the world. Research evidence suggests that males and females perform equally well in STEM fields and the gender gap in performance has closed, while some gender differences seem to appear in the kinds of courses taken within STEM fields. This study seeks to challenge the negative stereotypes and socially constructed myths about females' abilities and skills in Computing by investigating possible gender differences in student performance in Computing courses, by identifying similar patterns in STEM fields and by revealing possible differences in gender preferences in specific domains in Computing. In that sense, it is expected to add valuable information to the research findings in the field of gender differences in Computing from a case study in Greece. Thus, the abductive reasoning was judged appropriate to be the research approach for *Study2*.

Study3: Research in Computing and STEM fields has revealed that females face negative stereotypes about their abilities that may affect their self-efficacy beliefs and consequently their actual performance in Computing and STEM. This study attempts to investigate Computing teachers' gender-related beliefs and their relationship with their actual (gendered) teaching practices in class would uncover whether teachers' beliefs stem from stereotypes about gender differences in CS and guide their practices in affecting female students' engagement in Computing. Since this is the first empirical study investigating Computing teachers' gender-related beliefs and practices, it looks to challenge the socially constructed myths about girls' abilities in Computing and is expected to provide valuable evidence in the field.

4.4.2 Research Design

So far the outer two layers of the research onion have been peeled away. The next three layers, namely *research strategies*, *research choices* and *time horizons*, can be thought of as focusing on the process of research design, that is, turning the research questions into a research project (Robson, 2011).

4.4.2.1 Research strategy. A research strategy gives the research a direction and shapes the process by which it is conducted (Saunders et al., 2019). It can be referred to as a general way which helps the researcher to choose main data collection methods or sets of methods in order to answer the research question and meet the research objectives (Melnikovas, 2018).

A case study is defined as a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple source of evidence (Robson 2011, as cited in Saunders et al., 2009). It is a research method that involves an up-close, in-depth, and detailed examination of a subject of study (the case), as well as its related contextual conditions. This strategy has considerable ability to generate answers to question “what?” and “how?”. Single case studies provide the opportunity to observe and analyze phenomena that have not considered before, either the analysis is based on the systemic approach of a phenomenon/entity (*holistic* case study) or focuses on logical sub-units of a specific phenomenon/entity (*embedded-single* case study*)* (Yin, 2017).

The adopted strategy for *Study1* is an *embedded-single case study*, while for *Study2* and *3* is *holistic-single case study*. In particular:

Study1: The adopted *strategy* in this research is an *embedded–single case study*. In fact, Greek education is picked as the case, involving three sub–units of analysis: (a) teachers in C+STEM secondary education, (b) students in C+STEM tertiary education, and (c) faculty members in C+STEM tertiary education.

Study2: The gender differences in student preferences and performance is systematically analyzed in the context of a single CS dept. The Department of Computer Science and Technology (DCS&T), University of the Peloponnese in Greece –as a CS Tertiary Educational institution– was selected for the case study, comprising the total sum of graduate degrees earned from the first graduation in 2008 until and including those of 2012. This is a *holistic-single case study* which allows the examination of gender differences in terms of performance and course preferences as contemporary real-life phenomena within a CS, Tertiary Education context.

Study3: The investigation of CTs’ gender-related beliefs and actual teaching practices exploring possible associations between CTs’ beliefs and their actual teaching is systematically approached through structured observations and semi-structured interviews with 20 male and female CTs in Greece. In that sense, this study is a *holistic-single case study.*

4.4.2.3 Research choices. Saunders et al. (2009) define research choices with reference to the use of quantitative and qualitative research methods, as well as the simple or complex mix of both or the use of mono methods. Quantitative research methods refer to data collection techniques or data analysis procedure that generates or uses numerical data, while qualitative methods imply collection and analysis of descriptive data (Saunders et al., 2009). When the research is focused either on quantitative or qualitative data gathering the research method followed is mono method, while when both quantitative and qualitative data collection techniques and analysis procedures are employed within the same research, mixed method research is employed.

The research choice for *Studies 1* and *2* is *mono method quantitative*, while for *Study3* the selected research strategy is *mixed methods (quantitative – structured observations; qualitative – semi structured interviews)*.

4.4.2.4 Time horizons. This layer defines the time frame for research. Saunders et al. (2009) defines two time horizons: the 'snapshot' time horizon called *cross-sectional* and the 'diary' perspective called *longitudinal*. A cross-sectional study involves collection of data at a specific point of time in order to study a particular phenomenon at a particular short period of time (Saunders et al., 2009). On the other hand, longitudinal research refers to collection of data repeatedly over a long period of time in order to compare data. The main strength of longitudinal research is the capacity that it has to study change and development.

For this thesis, *Study1* is a longitudinal research, as it employs data for a whole decade studying trends and comparing values, while *Studies 2* and *3* constitute cross-sectional research, studying a particular phenomenon, student preference/performance and CT beliefs/practices respectively, at a specific point in time.

4.4.3 Techniques and Procedures

4.4.3.1 Data collection. Data collection is a process of collecting information from all the relevant sources to find answers to the research problem. Data collection methods can be divided into two categories: secondary methods of data collection and primary methods of data collection. Secondary data refers to data collected by someone other than the user. In other words, secondary data refers to data that have already been collected for some other purpose. Yet, such data may be very useful for one's research purpose. On the contrary, primary data is directly obtained from first-hand sources by means of questionnaire, observation, focus group, or in-depth interviews (Saunders et al., 2009).

Secondary data. Secondary data include both quantitative and qualitative data, and may be *raw* data, where there has been little if any processing, or *compiled* data that have received some form of selection or summarizing (Saunders et al., 2009). Such data are used most frequently as part of a case study. Saunders et al. (2009) have created three main sub-groups of secondary data: documentary data, survey-based data and those compiled from multiple source. *Documentary* secondary data can be *written* material, such as notices, records, reports etc., or *non-written* material, such as voice and video recordings, pictures, films, etc. For the purpose of the *Study2 of the* present thesis *documentary secondary written material* were collected. Survey-based secondary data refers to data collected using a survey strategy that have already been analyzed for their original purpose, while multiple-source secondary data can be based entirely on documentary or on survey secondary data. One of the more common types of multiple-source data in document form is various compilations of data derived from organizations reports or government publications. One method of compilation is to extract and combine selected comparable secondary data to provide a *time-series* of data. In this way it is possible to get data over a long period to undertake an longitudinal study. This is exactly the case for *Study1* of this thesis, where *time-series based secondary data* were employed.

Primary data. Primary data may be collected through observations, interviews and questionnaires. Focusing on *observations* it can be of two different types: *participant observation* which is qualitative and emphasis on discovering the meanings that people attach to their actions, and *structured observation* which is quantitative and is more concerned with the frequency of those actions (Saunders et al., 2009). Concentrating on structured observations, they are systematic and have high level of predetermined structure. A structured observation aims at quantifying behavior and their function is to tell researcher how often things happen rather than why they happen and allows the collection of data at the time they occur in their natural setting (Saunders et al., 2009).

Apart from observation, interviews can help the researcher to gather valid and reliable primary data that are relevant to his/her research questions and objectives.

Interviews may be highly formalized and structured, using standardized questions for each research participant, or they may be informal and unstructured conversations. In between there are intermediate positions (Saunders et al., 2009). Interviews in terms of formality and structure may be categorized as *structured*, *semi-structured* interviews, or *unstructured*/in-depth interviews. Another differentiation is between standardized interviews and non-standardized interviews. As opposed to unstructured interviews that are informal without a predetermined set of questions, structured interviews use questionnaires based on a predetermined and ‘standardized’ or identical set of questions, while in *semi-structured interviews* the researcher will have a list of themes and questions to be covered, although these may vary from interview to interview. Each form of interview has a distinct purpose. Standardized interviews are normally used to gather data, which will then be the subject of quantitative analysis, while *non-standardized* (semi-structured) interviews are used to gather data, which are analyzed qualitatively. *Study3* of the present thesis employs mixed primary data collection methods; *non-standardized/semi-structured interviews/one to one/face to face* interviews for eliciting teachers beliefs and *structured observations* to study their actual practices in class.

Sampling. For some research questions and objectives it is possible to collect and analyze data from every possible case, while for others it is impossible either to collect or to analyze all the data available due to restrictions of time, money and often access. In those cases a sample need to be selected. The sampling techniques are divided into two types: probability or representative sampling and non-probability or judgmental sampling. With *probability sampling* the chance of each case being selected from the population is known and is usually equal for all cases, while for *non-probability samples*, the probability of each case being selected from the total population is not known and it is impossible to answer research questions or to address objectives that require statistical inferences about the characteristics of the population (Saunders et al., 2009). Focusing on the non-probability sampling, there is a range of available non-probability sampling techniques, from those techniques which, like probability samples, try to represent the total population to techniques that there is no attempt to obtain a representative sample which will allow generalization in a statistical sense to the population. *Convenience sampling* is a non-probability sampling technique that involves selecting haphazardly those cases that are easiest to obtain, until the required sample size has been reached. Although this technique of sampling is prone to bias and influences that may be beyond of the control of the researcher, it is widely used in those cases where there are restrictions of time or access. For *Stud 3* of the present thesis, *convenience sampling* was employed, as the aim was not to generalize to the population of Computing teachers but to gain some valuable knowledge about Computing teachers' gender-related beliefs and practices. *Study1* studies the whole population in the Greek CS Education (secondary school teachers, undergraduate/graduate students, faculty members), while *Study2* refers to an *individual case* in the Greek Tertiary CS Education.

4.4.3.2 Data analysis. Data analysis is the process of extracting information from data, which can be *quantitative* or *qualitative*. Quantitative data refer to numerical data or data that could usefully be quantified to answer the research questions and to meet the objectives. Quantitative analysis techniques help to explore, present, describe and examine relationships and trends within the data. On the other hand, qualitative data refers to all non-numeric data or data that have not been quantified. To be useful these data need to be analyzed and the meanings understood. The non-standardized and complex nature of qualitative data "need to be condensed, categorized or restructured as a narrative to support meaningful analysis" (Saunders et al., 2009, p. 482).

For the purpose of *Study1* and *Study2* of this thesis quantitative data were collected and, subsequently, *quantitative analysis* of those data was implemented. For *Study3* both qualitative (from the interviews) and quantitative (from the structured observations) data were gathered. The data from the interviews were first analyzed *qualitatively* and subsequently *quantitatively*, while the data derived from the observations were analyzed *quantitatively*. The data collection and the data analysis procedures are discussed in detail in the corresponding chapter of each of the *Studies* which were realized to fulfill the aims of this research.

4.4.4 Reliability, Validity and Ethics of Research

4.4.4.1 Reliability and validity. Reliability and validity of research findings establish the basis on which other researchers should regard a piece of research as knowledge that can be assimilated into the knowledge base of a field of study (Rowley, 2002). It is therefore important to demonstrate that these issues have been fully considered.

Reliability. Reliability means the stability and repeatability of measures, or the ability of a test to produce the same results under the same conditions (Saunders et al., 2009). To ensure reliability the research design of *Studies 1*, *2*, and *3* in the present thesis was based on the research onion (Saunders et al., 2009), so it is possible for another researcher to repeat the research by uncovering the layers of the model. All the additional information, such as transcriptions of interviews, the statistics from the data analysis and NVivo data are presented in the appendices of this thesis.

Validity. Validity is concerned with whether the findings are really about what they appear to be about (Saunders et al., 2009). Validity is difficult to assess and has many dimensions. The following general categories of validity can help structure its assessment: *Construct validity* which refers to applying the appropriate and proper operational measures for the concepts that are under investigation (Yin, 2017); *external validity*, which concerns the extent to which the findings of a research can be generalized (Ibid), and *internal validity* which is about the validity of results within, or internal to, a study (Ibid) and usually concerns causality. Regarding *construct validity*, *Study1* and *Study2* are quantitative studies employing quantitative secondary data from the national statistical service of Greece (Hellenic Statistical Authority – ELSTAT) and valid and official university records, while for *Study3* the researcher collected data through multiple sources of evidence (interview, observation) and has "established chain of evidence" by citing documents and interviews in an appropriate manner (Rowley, 2002, p. 21). Concerning *external validity*, for *Study1* the researcher attempted to investigate the gender representation in Greek CS education uncovering the extend of the gender gap in CS in Greece and providing a reference point for the Greek case. For *Study2* the researcher's main concern was to gain an insight in gender differences in performance and preference in CS providing empirical data from a case study in Greece which could be compared to theories and results from related studies contributing to the dispute on gender gap in Computing. Regarding *Study3*, the researcher has attempted to elicit Computing teachers' beliefs and investigate their actual practices in class. The generalization in this case was that of analytical generalization in which a developed theory about teachers' gender-related beliefs is compared to the empirical findings of this case study (Rowley, 2002). Regarding internal validity, since the current studies are not explanatory ones, it does not constitute a matter of concern.

4.4.4.2 Ethics of research. Research ethics is related to design of research, gain access, collect data, process and store of data as well as analyze data and present research findings (Saunders et al., 2009). The researcher has ensured that the design of the research for the individual studies of this thesis were both methodologically sound and morally defensible to all those who were involved. For *Study1* the data regarding teachers were taken from the ELSTAT and were referred only to the gender of the teachers during the decade under study, while for the gender representation of students/graduates and faculty in Tertiary education the data collected from ELSTAT were referred also just to students' and faculties' gender and were classified to disciplines (Computing and STEM) according to the International Standard Classification of Education (ISCED) developed by UNESCO. Regarding *Study2* the data concerning the graduates were collected from the official records of the Computing dept under study without any reference to the personal data of the graduates apart from their gender. Those data referred to the gender of each graduate, the courses that she/he had enrolled and successfully examined along with her/his grades. Finally, concerning *Study3* in order to conduct research, firstly official approval was requested by the Hellenic Ministry of Education, Research and Religious Affairs, and then the principals and the teachers of the selected schools were informed and their consensus to participate to the study was granted. Next, the parents of the students in the selected classes were informed about the research experiment and their consent was also confirmed (see Appendix III.4). To preserve anonymity, the schools and the CTs observed and interviewed are not identified by name. Overall, ethical standards, reliability and validity of the data collection and statistical analysis were followed for the best result.

Section C. Research: Context of the Studies and Results

Chapter 5

Gender Representation in Computing Education in Greece

Summary: The following chapter presents a detailed description of the context and the results of *'Study1: Gender representation in Computing Education in Greece'* of this thesis. The main research findings are also discussed as a response to the research questions posed within the context of the first aim of this dissertation.

5.1 Context of Study1

5.1.1 Aim of the Study

The aim of *Study1* is mainly threefold and specifically to *systematically investigate* for the decade 2003–12: (a) teacher gender representation in C+STEM Greek Secondary Education (GSE) (see sub-aim 1.1 of the thesis; chapter 4; section 4.1.1), (b) student gender representation in C+STEM GTE (see sub-aim 1.2 of the thesis; chapter 4; section 4.1.2), and (c) faculty member gender representation in C+STEM Greek Tertiary Education (GTE) (see sub-aim 1.3 of the thesis; chapter 4; section 4.1.3). For each of these sub-aims two research questions were posed: for sub–aim 1.1: RQ1.1.i and RQ1.1.ii (see chapter 4, section 4.1.1); for sub-aim 1.2: RQ1.2.i and RQ1.2.ii (see chapter 4, section 4.1.2); for sub-aim 1.3: RQ1.3.i and RQ1.3.ii (see chapter 4, section 4.1.3).

5.1.2 Methodological Choices

The methodological choices of *Study1* were fully presented in the *'Research Methodology'* chapter of the thesis, except the collection and the analysis of the data employed in this study which are discussed next.

5.1.2.1 Data collection. For this research time–series secondary data were collected. The data regards the decade 2003 to 2012 and were derived from the Hellenic Statistical Authority (EL.STAT), which is the national statistical service of Greece (http://www.statistics.gr/). The data collection concerns: (a) teachers in C+STEM GSE, (b) students in C+STEM GTE, and (c) faculty members in C+STEM GTE.

Teachers in C+STEM GSE. Before the description of the collection of the data the following clarification would be helpful for a reader who is not familiar with the Greek education system. 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 Vocational Lyceum (VL) – which is technically oriented. Computing and STEM disciplines (Physics, Mathematics, Engineering) are included in the Greek secondary student curricula and C+STEM teachers teach in both of the aforementioned levels of education.

Regarding the data collection, EL.STAT provides the total number of teachers and the number of female teachers, in Greece, each year per discipline, in terms of different levels of education, namely: Gymnasium, GL and VL. For the purpose of this study, for each year of the decade 2003 to 2012, for the three different level of education raw data were collected that concern the permanently appointed teachers in: (a) all disciplines (*'Overall'*); *'Computing'*; *Mathematics* ('Math'); '*Science'*) –including physicists, chemists, biologists; Engineers (*'Eng'*)– including civil, mechanical, electrical engineers, architects and others engineers that can teach in high school. The data collected cover the period from the beginning of 2003/04 (in fact year 2003) to the beginning of 2012/13 (in fact year 2012).

Students in C+STEM GTE: As regards student representation, EL.STAT presents the total number of students and the number of females each year per dept in terms of different categories of students/graduates, namely: freshmen, graduates, master's degree graduates and PhD graduates. 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 *('Overall')*, for each year of the decade, and for each discipline (university and engineering depts) as well as for each student–category (freshmen, graduates, master's degree graduates and PhD graduates). The data regarding students and graduates cover the period from the end of 2002/03 (in fact year 2003) to the end of 2011/12 (in fact year 2012).

Faculty members in C+STEM tertiary education: As regards faculty representation, EL.STAT presents the total number of faculty members and the number of females each year on average per dept, in terms of different categories of faculty, namely: professors, associate professors, assistant professors and lecturers. The data regarding faculty members cover the period from the beginning of 2003/04 to the beginning of 2012/13.

5.1.2.2 Data analysis. In order to analyze the data, statistical analysis was performed. To calculate the results, the Statistical Package for Social Sciences (SPSS) v.24.0 was used. Due to the fact that, this study refers to the whole population of teachers, students and faculty members in Greece during the studied decade descriptive statistics was considered appropriate to be used. The analysis of the data is presented below and concerns: (a) teachers in C+STEM GSE, (b) students in C+STEM GTE, and (c) faculty members in C+STEM GTE.

Teachers in C+STEM GSE. Based on the raw data collected, (a) the percentages of female teachers for each year/discipline/level of education were calculated and organized in Tables which are presented in the 'Results' section of this chapter. (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.

Students in C+STEM GTE. The data concerning student representation was classified for every year of the decade, by the researcher into the following disciplines of C+STEM education, taking into account the International Standard Classification of Education (ISCED) developed by UNESCO (see Appendix I for a detailed list of the Greek University departments and Engineering Schools that fall into each of the disciplines):

- *'Computing':* CS & Computer Engineering (including 14 Computing University depts and 8 Electrical & Computer Engineering Schools)
- *'Bio/Env':* Biological Sciences and Environment (including 7 University depts covering Biology, Genetics and Marine Sciences)
- *'Phys':* Physical Sciences (including 14 University depts covering Physics, Chemistry, Geology and Material Sciences)
- *'Math':* Mathematics and Statistics (including 10 University depts covering Mathematics, Applied Mathematics and Statistics)
- *'Eng':* Engineering (including 18 University depts covering chemical, mechanical and other engineering–related technologies)

Regarding the analysis of the data, 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 chapter, (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.

Faculty members in C+STEM GTE: for each year of the decade under study, on average, the numbers of each of the categories of faculty members in Greek depts included in the field of Computing were calculated, as well as those in each specific field of STEM education. The classification into C+STEM disciplines (*'Computing'*; *'Bio/Env*'; *'Phys'*; *'Math'*; *'Eng'*) was realized by the author taking into account the ISCED developed by UNESCO presented before. Concerning the data analysis, the total number of faculty members and the percentages of female faculty members, each year on average, in terms of discipline and category of faculty were calculated and organized in Tables which are presented in the 'Results' section of this chapter.

5.2 Study1: Results

The results from the analysis of the data are presented here in line with the three sub-aims of this study and specifically, in terms of : (a) teacher gender representation in C+STEM GSE (sub-aim 1.1; section 5.3.1), (b) student gender representation in C+STEM GTE (sub-aim 1.2; section 5.3.2), and (c) faculty member gender representation in C+STEM GTE (sub-aim 1.3; section 5.3.3).

Each of these sections presents: (i) the teacher/student/faculty *gender representation* in C+STEM GSE/GTE, aiming at answering the research questions of this study (RQ.1.1.i; RQ.1.2.i; RQ.1.3.i), and (ii) the *comparison* of the teacher/student/faculty female representation in Computing with the corresponding representation in the rest of the STEM disciplines in GSE/GTE, targeting at answering *ii* research questions of this study (RQ.1.1.ii; RQ.1.2.ii; RQ.1.3.ii).

Regarding *gender representation*, the results are organized into Tables that demonstrate the number of males and females [(N) for teachers/students/faculty] and number of degrees awarded to males and females [(NoD) for graduates], as well as the percentage of those who were females (F%) in C+STEM GSE/GTE for every single year of the decade under study. The mean (M) and the standard deviation (SD) of the percentage of females (F%) are also presented in the last row of these Tables.

Concerning the *comparison of the female representation among the disciplines*, this is realized in terms of: (a) trends of female percentages within the decade in question (illustrated in Figures; run charts), (b) mean values of female percentages of the studied decade (portrayed in Figures; clustered bar charts), and (c) mean values of numbers of female teachers/students/faculty members (depicted in Figures; clustered bar charts and stacked bar charts).

5.2.1 Teacher Gender Representation in C+STEM Greek Secondary Education

The results from the data analysis are presented here in terms of: (a) teacher gender representation in C+STEM GSE (Gymnasium and Lyceum), (b) comparison of female teacher representation among disciplines.

5.2.1.1 Teacher gender representation in C+STEM in Greek Junior High School (Gymnasium). The results from the data analysis regarding teachers in all Greek Gymnasium are presented in Table 1 in terms of: (a) teachers from all disciplines (*'Overall'*), (b) *'Computing'* teachers, (c) *'Science'* teachers and (d) *'Math'* teachers.

Overall. As can be seen from Table 1 (column 3), female Gymnasium teachers outnumber their male counterparts in every single year of the decade under study. The percentage varies from 64.56 to 66.49%. Despite the fact that the total number of teachers continuously decreased (see Table 1; column 2), starting from 41,865 (in 2006/07) and ending in 35,636 (at 2012/13), the percentage of female teachers overall remained stable. In fact, the average percentage of female teachers in Greek Gymnasium during the abovementioned decade was 65.66% (SD=0.55).

Computing. As it is shown in Table 1 (column 5), there are fewer female than male *'Computing'* teachers in Gymnasium in every year of the decade. The percentage varies from 44.86 to 46.77%. The total number of *'Computing'* teachers 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 teachers in Gymnasium during the decade in question was 45.93% (SD=0.54).

Table 1

Teacher gender representation in C+STEM Greek Secondary Education (Gymnasium): 2003–2012

Start of School Year	Overall		Computing		Science		Math	
	N	F%	N	F%	N	F%	N	F%
2003/04	36,853	64.56	1438	45.69	4348	41.63	4159	34.77
2004/05	39,225	65.31	1585	44.86	4562	42.59	4294	35.54
2005/06	40,788	64.99	1672	45.69	4637	42.96	4384	35.7
2006/07	41,865	65.67	2111	46.14	4755	42.73	4430	35.89
2007/08	41,174	65.95	2106	46.77	4832	43.65	4510	36.7
2008/09	39,376	66.14	2173	45.56	4977	43.92	4646	38.27
2009/10	39,250	65.57	2182	46.38	4979	43.60	4638	39.05
2010/11	37,679	65.72	2253	45.85	5037	44.25	4480	39.49
2011/12	37,160	66.09	2202	45.73	4744	44.81	4300	40.16
2012/13	35,636	66.49	2153	46.63	4400	44.16	3987	41.56
Average	38,901	M=65.66 SD=0.55	1,988	M=45.93 SD=0.54	47,27	M=43.43 SD=0.90	4,383	M=37.71 SD=2.19

Science. Similarly, there were fewer female *'Science'* teachers in Gymnasium than their male colleagues every single year of the aforementioned decade (see Table 1; column 7), their percentage varying from 41.63 to 44.81%. The total number of *'Science'* teachers increased from 2003/04 through 2010/11, although over the next 2 years it decreased considerably (see Table 1; column 6). On average, female *'Science'* teachers constituted 43.43% of the total number of *Science'* teachers (SD=0,9).

Math. Regarding female *'Math'* teachers, 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 1; column 9). The total number of *'Math'* teachers increased from 2003/04 to 2008/09, then decreased to 3,987 in 2012/13, a number even lower than that of 2002/03 (see Table 1; column 8). On average, the percentage of female *'Math'* teachers that decade was 37.71% of the total number of *'Math'* teachers (SD=2.19).

5.2.1.1 Teacher gender representation in C+STEM in Greek High School: General Lyceum and Vocational Lyceum

General Lyceum. The results from the data analysis regarding teachers in GL are presented in Table 2 in terms of: (a) teachers from all disciplines (*'Overall'*), (b) *'Computing'* teachers, (c) *'Science'* teachers and (d) *'Math'* teachers.

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

Computing. Female *'Computing'* teachers in GL were less prevalent than their male counterparts every single year of the decade (see Table 2; column 5), the percentage varying from 36.14 to 39.38%. On average, each year female *'Computing'* teachers constituted 37.91% of the *'Computing'* teaching staff at GL (SD=0.97). The number of *'Computing'* teachers in GL increased from 2003/04 to 2010/11 and decreased thereafter (see Table; column 4).

Science. Similarly, there were fewer female *'Science'* teachers in GL than their male colleagues every single year of the mentioned decade (see Table 2; column 7). The percentage of female *'Science'* teachers varies from 21.74 to 30.31%, trending upward throughout the decade. On average, each year female *'Science'* teachers constituted 26.1% of the total *'Science'* teachers in GL (SD=2.9). The total number of *'Science'* teachers increased steadily from 2002/03 to 2009/10 (see Table 2; column 6).

Math. Female *'Math'* teachers in GL were less prevalent than their male counterparts every single year of the mentioned decade (see Table 2; column 9). The percentage of female *'Math'* teachers varies from 17.39 to 24.91%, trending upward to the end of the decade. On average, the percentage of female teachers in GL was 20.13% (SD=2.47). The number of *'Math'* teachers increased from 2002/03 to 2009/10 remaining more or less constant thereafter (see Table 2; column 8).

Vocational Lyceum. The results from the data analysis regarding teachers in VL are presented in this sections in terms of teachers from: (a) all disciplines (*'Overall'*), (b) *'Computing'*, (c) *'Science'*, (d) *'Math'* and (e) *'Eng'*.

Overall. In VL, there were, *'Overall'*, fewer female teachers than male teachers in every year of the mentioned decade (see Table 2; column 11). The percentage varied from 41.52% to 45.79%. On average, the percentage of female teachers in VL was 43.09% (SD=1.78). The total number of teachers in VL fluctuated during the decade in question, with an average of 16,766 teachers per year (see Table 2; column 11).

Computing. Female *'Computing'* teachers were less prevalent than male teachers every year of the decade (see Table 2, column 13). The percentage varied from 33.68 to 37.49%. On average, each year female *'Computing'* teachers constituted 35.66% (SD=1.15) of the *'Computing'* teaching staff in VL. The number of non–female *'Computing'* teachers in VL increased during the first year of the aforementioned decade but decreased thereafter (see Table 2; column 12).

Science. Similarly to *'Computing'*, there were fewer female *'Science'* teachers in VL than male teachers in every year of the decade (see Table 2, column 15). The percentage varied from 32.54% to 39.37%. On average, the percentage of female *'Science'* teachers in VL was 35.51% (SD=1.97).

Math: Female *'Math'* teachers in VL were also less prevalent than their male counterparts in every year of the decade (see Table 2, column 17). The percentage varied from 27.91 to 43.42%. On average, the percentage of female *'Math'* teachers in VL was 33.74% (SD=5.02).

Table 2

Teacher gender representation in C+STEM Greek Secondary Education (General and Vocational Lyceum): 2003–2012

End of Academic Year	General High School (General Lyceum).								Vocational High School (Vocational Lyceum)									
	Overall		Computing		Science		Math		Overall		Computing		Science		Math		Eng	
	N	F%	NoD	F%	NoD	F%	NoD	F%	NoD	F%	NoD	F%	NoD	F%	NoD	F%	NoD	F%
2002/03	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
2003/04	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**
2004/05	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
2005/06	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
2006/07	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
2007/08	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
2008/09	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
2009/10	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
2010/11	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
2011/12	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 SD=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

Note. Bold items represent the minimum and the maximum values in percentage columns

Eng: *'Eng'* teachers teach only in VL. Each year of the decade saw fewer female *'Eng'* teachers than their male colleagues (see Table 2, column 19). The percentage varied from 22.42 to 24.80%. On average, the percentage of female *'Eng'* teachers in VL was 23.71% (SD=0.84).

Cross sectional analysis. A comparative analysis in terms of total numbers of teachers and female representation, *'Overall'* and for each one of the studied disciplines, across the levels of the Greek secondary education (Gymnasium, GL and VL) is presented in this section.

Overall. There were fewer teachers in GL (on average 25,263) compared to their colleagues in Gymnasium (on average 38,901) but considerably more than those in VL (on average 16,766). The representation of female teachers in Gymnasium (on average 65.66%) is notably better than in GL (on average 51.36%) and VL (on average 43.09%).

Computing. On average, the number of *'Computing'* teachers in Gymnasium was 1,988, in VL 1,724 and in GL 1,434. There were, on average, 914 female *'Computing'* teachers in Gymnasium every year, while in GL this number was 544 and in VL 615. However, on average, female *'Computing'* teachers are better represented in Gymnasium (45.93%), compared to GL and VL (37.91% and 35.66% respectively).

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

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

5.2.1.2 Comparison between female–teacher representation in C+STEM Greek secondary education: trends and mean values

Trends. Figure 6, Figure 7 and Figure 8 demonstrate diagrammatically –in terms of percentages– the trends in female teacher representation in *'Computing'*, *'Science'*, *'Math'* and *'Overall'*, from the start of the school year 2003/04 through the start of the school year 2012/2013 for different levels of secondary education; namely: Gymnasium (Figure 6), General Lyceum (Figure 7), and Vocational Lyceum (Figure 8).

Gymnasium. Figure 6 illustrates that, *'Overall'*, the percentage of female teachers remained steadily over 60%, indicating that during the whole decade female teachers were more than males. The percentage of female *'Computing'* teachers remained around 45% the whole decade, being the best represented among STEM disciplines. Despite the fact that the percentage of female *'Math'* teachers appeared an upward trend throughout the decade, female *'Math'* teachers' percentages are the worst in C+STEM disciplines. Female *'Science'* teachers' percentages are close but lower that female *'Computing'* teachers' throughout the decade.

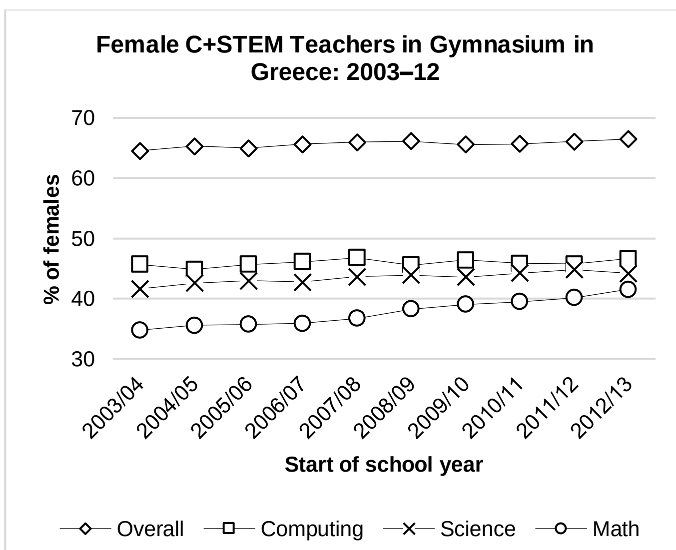


Figure 6. Female C+STEM teachers in Gymnasium in Greece: trends; 2003–12.

General Lyceum. Figure 7 indicates that, *'Overall'*, the percentage of female teachers followed an upward trend throughout the decade, exceeding 50% in 2006/07 and remaining over 50% for the rest of the decade.

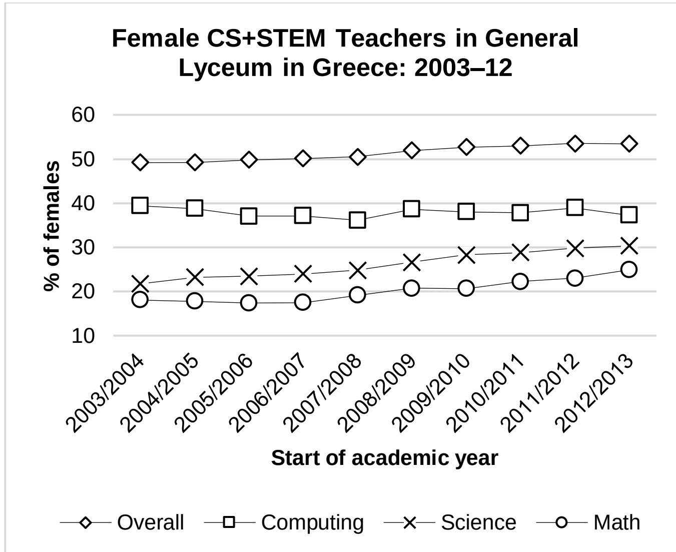


Figure 7. Female C+STEM teachers in General Lyceum in Greece: trends; 2003–12

The percentage of female *'Computing'* teachers in GL fluctuated throughout the decade, remaining just below 40%, being the best among the rest of the STEM disciplines. The percentages of female *'Science'* and *'Math'* teachers appeared a clear upward trend throughout the decade, but remained below 30% the whole decade. Just like in Gymnasium, female *'Math'* teachers' percentages are the worst in C+STEM disciplines in GL.

Vocational Lyceum. Figure 8 illustrates that *'Overall'* and in C+STEM disciplines female teachers were less than males every single year of the decade under study. The percentage of female teacher *'Overall'* was the highest for almost all of the years of the decade, while female *'Eng'* teachers' percentages were the worst among C+STEM disciplines.

Female *'Computing'* teachers' percentages in VL were the best among STEM disciplines for the first five years of the decade, but the mostly upward trends of the percentages of female *'Math'* and *'Phys'* teachers throughout the decade, made the female *'Computing'* teachers' percentage the second worst among STEM at the end of the studied decade.

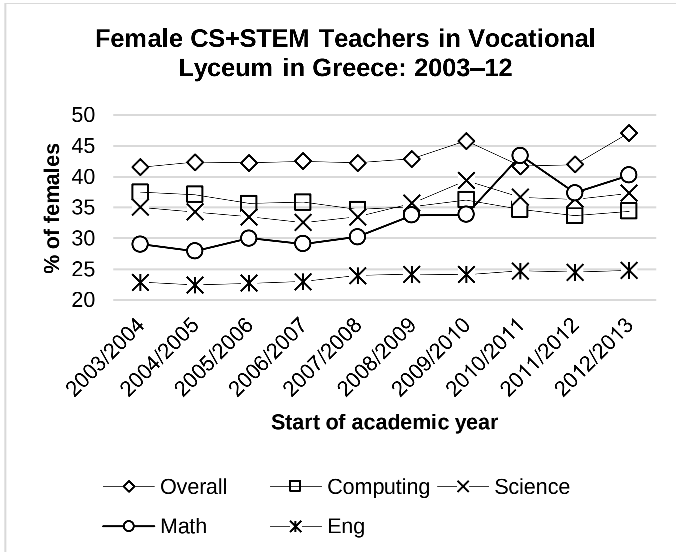


Figure 8. Female C+STEM teachers in Vocational Lyceum in Greece: trends; 2003–12

Mean values of the decade: percentages and numbers

Gymnasium. Overall, from an average of 38,901 teachers in Gymnasium during the said decade, 25,542 (65.66%) were female, 4,727 were *'Science'* teachers (12.15%), 4,383 were *'Math'* teachers (11.27%) and just 1,988 were *'Computing'* teachers (5.11%). On the whole, despite the fact that *'Computing'* teachers 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 *'Science'* (43.43%) and *'Math'* (37.71%) (see

Figure 9. Percentages of female teacher representation in C+STEM GSE: mean values; 2003–12

). However, numerically, on average, there were more female *'Science'* teachers (2,053) than female *'Math'* teachers (1,653) and female *'Computing'* teachers (914) (see Figure 10).

General Lyceum. In GL, on average, every year of the mentioned decade, there were 25,263 teachers, of which 12,972 (51.35%) were female. 4,315 of them were *'Math'* teachers (17.09%), 4,168 *'Phys'* teachers (16.50%) and only 1,434 *'Computing'* teachers (5.68%). However, despite the fact that *'Computing'* teachers 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 *'Science'* (26.10%) and *'Math'* (20.13%) (see

Figure 9. Percentages of female teacher representation in C+STEM GSE: mean values; 2003–12

). Nevertheless, on average, female *'Science'* teachers (1,088) were more prevalent than female *'Math'* teachers (869) and greater in number than female *'Computing'* teachers (544) (see Figure 10).

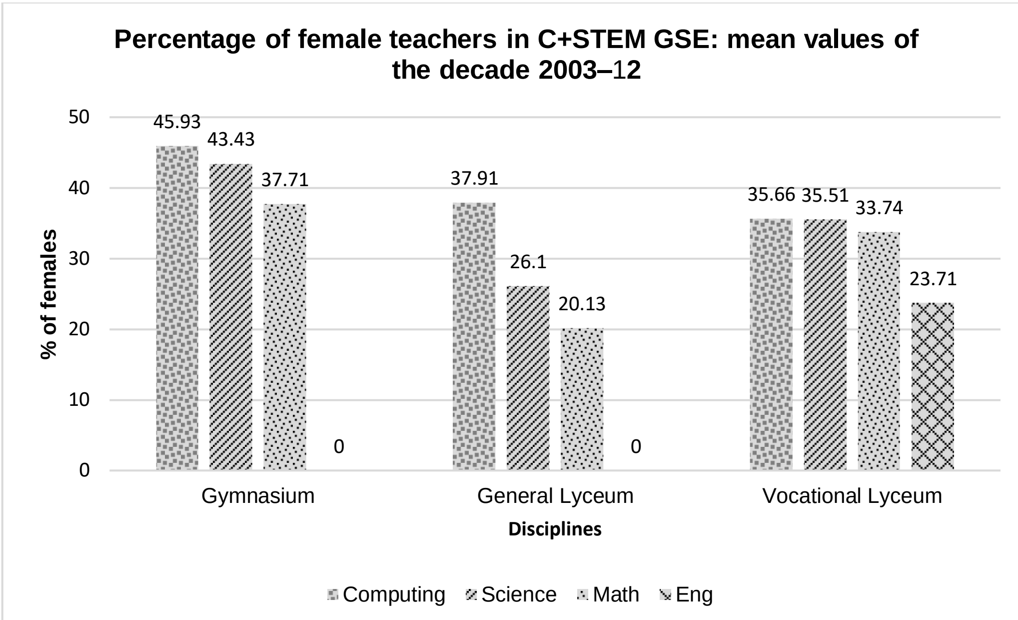


Figure 9. Percentages of female teacher representation in C+STEM GSE: mean values; 2003–12

Vocational Lyceum. In VL, on average, in every year of the aforementioned decade, there were 16,766 teachers of all disciplines. 1,724 of them were *'Computing'* teachers (10.28%), 1,072 *'Math'* teachers (6.39%), 884 *'Science'* teachers (5.27%), and 873 *'Eng'* teachers (5.21%). There were more *'Computing'* teachers in VL than teachers in related STEM disciplines, and female teachers were better represented in the *'Computing'* teaching staff (35.66%) compared to the representation of female teachers of other related disciplines, e.g. *'Science'* (35.51%), *'Math'* (33.74%) and *'Eng'* (23.71%) (see Figure 9). It is worth noting here that, on average, every year there were more female *'Computing'* teachers (615) than female *'Math'* teachers (362), female *'Science'* teachers (314), and female *'Eng'* teachers (207) (see Figure 10). Numerically, on average, there were fewer female *'Math'* teachers (1652) than female *'Science'* teachers (2052) but more than female Computing teachers (918) (see Figure 10).

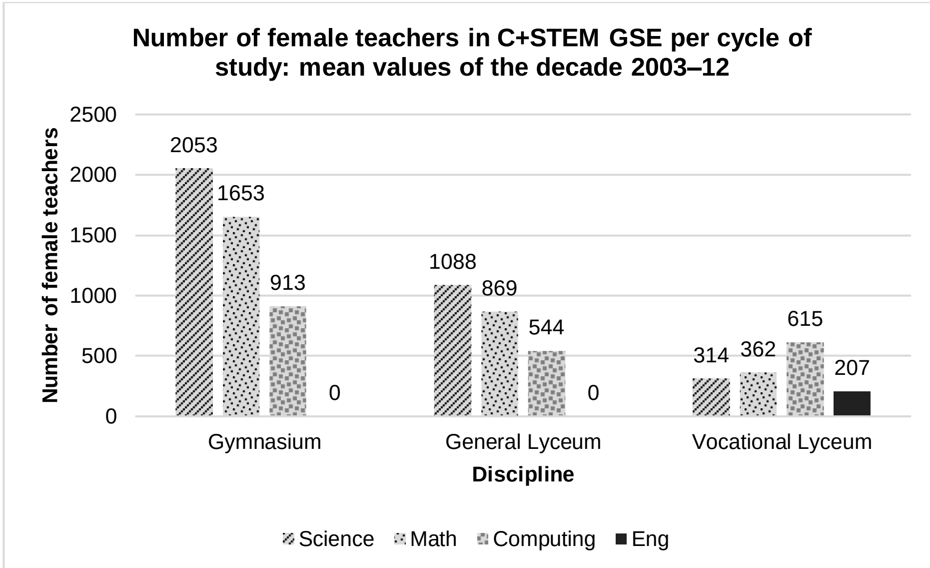


Figure 10. Number of female teachers in C+STEM GSE: mean values; 2003–12

Overall, a comparison of the total number of female teachers in GSE reveals that, numerically, on average there are more female *'Science'* and *'Math'* teachers compared to female *'Computing'* teachers (see Figure 11)

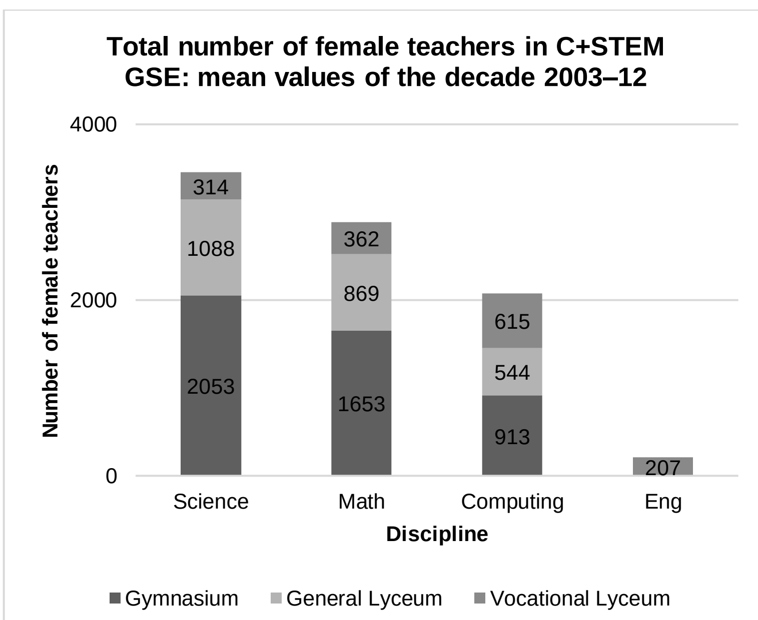


Figure 11. Total number of female teachers in C+STEM GSE: mean values; 2003–12

5.2.2 Student Gender Representation in C+STEM Greek Tertiary Education

The results from the data analysis concern the decade 2003–12 (end of the academic year 2002/03 to the end of 2011/12) and are presented here in terms of: (a) student gender representation in C+STEM Tertiary education in Greece, (b) comparison of female faculty member representation in Computing with that in the remaining fields of STEM education in Greece.

5.2.2.1 Gender representation of students in C+STEM in Greek Tertiary education: 2003–2012

The results from the data analysis regarding students and graduates C+STEM GTE presented in this section in respect to all Greek: (a) Universities and Engineering Schools (*'Overall'*), and *'Computing'* depts (in Table 3), (b) *'Bio/Env'* and *'Phys'* depts (Table 4), and (c) *'Math'* and *'Eng'* depts (in Table 5).

Overall. As can be seen from Table 3, 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 3; columns, 3, 5 and 7). The percentage of female freshmen varies from 59.30 to 61.80% (see Table 3; column, 3), the percentage of female graduates varies from 62.99 to 64.97% (see Table 3; column, 5), while the percentage of female Master's Degree graduates varies from 54.05% to 61.63% (see Table 3; 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 3; column, 9). On average, of the 41,009 freshmen, 60.53% (SD=0.81) were female, while of an average of 31,333 Bachelor's degree graduates, 6,917 master's degree graduates, and 1,567 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 3; cells of the last row of columns, 2, 3, 4, 6, 8, 5, 7 and 9 correspondingly)

Table 3

Student gender representation in Greek Tertiary Education, 2003-12: Overall and Computing

Student gender representation in GTE, 2003-121; *'Overall'* and *'Computing' depts*																
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%
2002/03	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**
2003/04	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
2004/05	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
2005/06	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
2006/07	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
2007/08	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
2008/09	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
2009/10	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
2010/11	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
2011/12	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**
Average	41,009	M=60.53	31,333	M=64.33	6,917	M=57.37	1,567	M=38.78	3,225	M=26.55	1,780	M=29.54	593	M=34.45	215	M=14.96
		SD=0.81		SD=0.58		SD=2.37		SD=4.22		SD=3.20		SD=3.11		SD=4.3		SD=3.15

Note. Bold items represent the minimum and the maximum values in percentage columns

Computing. As can be seen from Table 3, in every single year of the aforementioned decade there are fewer females than males in all four categories: freshmen, graduates, graduates of master's programs, and PhD graduates, with a percentage of less than 40.96% (see Table 3; columns, 11, 13, 15 and 17). The percentage of female freshmen in Computing depts varies from 21.81 to 30.85% (see Table 3; column, 11), steadily decreasing as the end of the decade approaches (see Table 3; 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 3; column, 13). The percentage of female master degree graduates in *'Computing'* varies from 25.63 to 40.96% (see Table 3; column, 15) while the percentage of female PhDs varies from 9.47 to 20.81% (see Table 3; column, 17). During the said decade, on average, of the 3,225 freshmen, 26.55% (SD=3.20) were female, while of the 1,780 undergraduate degrees, 593 master degrees and 215 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 3; cells of the last row of columns, 10, 11, 12, 14, 16, 13, 15 and 17 correspondingly). It is worth noting that despite the drop in the percentage of female freshmen in *'Computing'*, 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 4; 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 4; column, 7), while four years of the aforementioned decade experienced a greater number of female than male PhD graduates (see Table 4; column, 9).

Table 4

Student gender representation in Greek Tertiary Education, 2003–2012: Biology/Environment and Physics

Gender representation in GTE, 2003–12: 'Bio/Env' and 'Phys' depts																
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%
2002/03	804	67.16	257	64.98	49	40.82	12	58.33	2044	43.44	1515	**42.24**	367	**43.87**	101	26.73
2003/04	767	63.49	322	**61.49**	73	69.86	74	45.95	1930	43.83	1165	47.21	377	51.46	128	**25.00**
2004/05	760	68.16	447	64.21	90	63.33	27	48.15	1945	**42.11**	1115	45.92	446	44.17	88	42.05
2005/06	779	69.06	460	69.78	171	53.22	45	51.11	1958	44.99	1037	46.87	404	51.49	120	43.33
2006/07	768	68.10	369	73.71	126	65.08	45	57.78	1980	47.98	1071	46.13	422	49.29	161	39.75
2007/08	673	63.30	612	71.41	82	**57.32**	33	45.45	1870	47.54	1233	48.82	377	51.72	139	35.25
2008/09	754	66.71	540	73.33	151	74.17	72	55.56	1893	**51.24**	1110	50.00	450	45.78	142	**44.37**
2009/10	775	64.77	557	68.58	85	71.76	54	**70.37**	1929	50.03	1341	51.38	400	48.75	173	38.73
2010/11	734	**63.08**	575	**72.00**	205	64.88	59	54.24	1885	48.01	1314	**51.98**	429	49.42	135	35.56
2011/12	717	**68.76**	535	66.92	131	**74.05**	52	**36.54**	1895	50.50	1231	49.31	529	**55.58**	117	37.61
TOTAL	753	M=66.30 SD=2.26	467	M=69.15 SD=3.94	116	M=64.57 SD=9.98	47	M=52.22 SD=8.73	1,933	M=46.92 SD=3.04	1,213	M=47.96 SD=2.77	420	M=49.27 SD=3.51	130	M=37.04 SD=6.20

Note. Bold items represent the minimum and the maximum values in percentage columns

During the whole decade, of the 753 freshmen on average in Bio/Env, 66.30% (SD=2.26) were female, of the 467 undergraduate degrees, 116 master degrees and 47 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 4; 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.

Physics. 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 4; 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 4; column, 15). There are clearly fewer female than male PhD graduates in every single year of the decade (see Table 4; column, 17). In *'Phys'*, for the whole decade, on average, of the 1,933 freshmen, 46.92% (SD=3.04) were female, while of the 1,213 undergraduate degrees, 420 master's degrees and 130 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 4; 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 5, 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 5; 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 5; 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 5; columns, 7 and 9). During the whole decade, in *'Math'*, on average of the 2,200 freshmen, 47.86% (SD=2.39) were females, while of the 1,310 undergraduate degrees, 376 master degrees and 48 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 5; 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 5; 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 5; columns, 11, 13, 15 and 17 correspondingly). On average, of the 1,712 freshmen, 32.14% (SD=1.71) were female, while of the 1,049 degrees, 249 master's degrees and 98 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 5; 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 C+STEM and there was also no dropout from level (undergraduate studies) to level (master's degree studies) in *'Computing'*, *'Phys'* and *'Eng'* GTE.

Table 5

Student gender representation in Greek Tertiary Education, 2003–2012: Mathematics and Engineering

Student gender representation in GTE, 2003–2012: *'Math'* and *'Eng'*																
End of Academic Year	Math								Eng							
	Freshmen		Graduates		Master		PhD		Freshmen		Graduates		Master		PhD	
	N	F%	NoD	F%	NoD	F%	NoD	F%	N	F%	NoD	F%	NoD	F%	NoD	F%
2002/03	2,367	44.76	1,286	**45.41**	165	35.76	44	**38.64**	1809	30.79	1,085	**26.54**	209	**25.36**	80	27.50
2003/04	2,252	**42.56**	1,067	49.95	147	35.37	20	30.00	1724	**28.89**	700	27.39	282	34.04	98	29.59
2004/05	2,138	46.61	1,380	49.20	249	**34.54**	37	27.03	1697	31.88	1,160	31.81	269	40.15	64	**25.00**
2005/06	2,154	47.91	1,209	45.91	267	41.95	49	**20.41**	1539	31.32	721	28.83	290	33.79	56	33.93
2006/07	2,028	48.54	1,222	49.35	414	43.24	61	24.59	1568	32.65	842	33.73	264	35.23	86	**44.19**
2007/08	2,068	49.49	1,408	48.08	485	44.33	41	26.83	1550	33.03	1,081	35.62	268	39.18	87	29.89
2008/09	2,231	49.95	1,264	50.40	592	41.72	74	25.68	1747	**35.49**	1,187	30.16	240	35.83	114	35.96
2009/10	2,262	49.56	1,392	50.07	407	43.98	51	21.57	1832	33.84	1,305	**33.87**	186	48.92	162	34.57
2010/11	2,273	49.55	1,424	49.79	544	**45.96**	50	22.00	1793	32.35	1,208	32.78	199	**49.75**	128	28.91
2011/12	2,224	**49.98**	1,451	**51.21**	488	41.80	51	23.53	1858	31.16	1,201	30.56	281	47.69	105	29.52
Average	2,200	M=47.86	1,310	M=48.97	376	M=42.12	48	M=25.52	1,712	M=32.14	1,049	M=31.35	249	M=38.71	98	M=32.14
		SD=2.39		SD=1.81		SD=3.90		SD=5.03		SD=1.71		SD=2.81		SD=7.44		SD=5.19

Note. Bold items represent the minimum and the maximum values in percentage columns

5.2.2.2 Comparison between female–student representation in C+STEM education in Greece: trends and mean values

Trends. Figure 12 to Figure 15 display diagrammatically –in terms of percentages– the trends in female representation in *'Computing'*, the rest of STEM discipliens and *'Overall'*, from the end of the academic year 2002/03 through the end of academic year 2011/2012 for different levels of study; namely: freshmen (Figure 12), graduates of undergraduate studies (Figure 13), master's degrees graduates (Figure 14), and PhD graduates (Figure 15).

Freshmen. Figure 12 illustrates that, during the decade, the percentage of female freshmen *'Overall'* steadily remains close to 60%, while the percentage of female freshmen in '*Bio/Env'* clearly remains over 60%, approaching 70% in certain years.

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 that the percentage of female freshmen decreases steadily throughout the decade, resulting in a very low percentage of just over 20%.

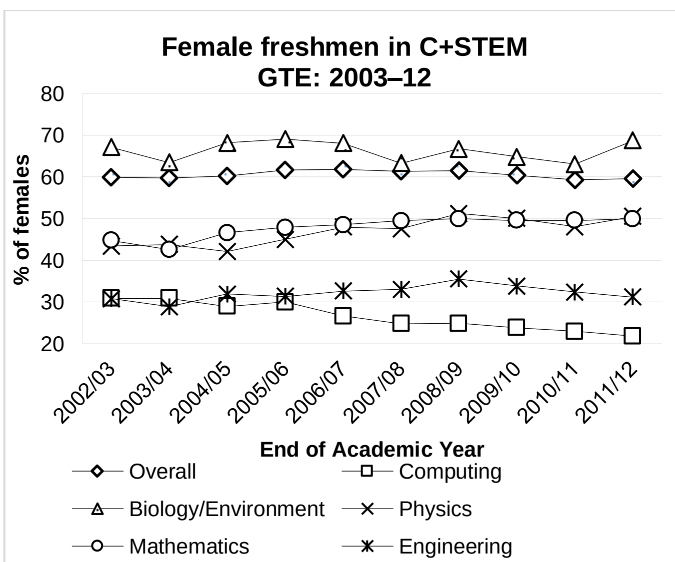


Figure 12. Female freshmen representation in C+STEM GTE: 2003–12

Graduates. Figure 13 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%.

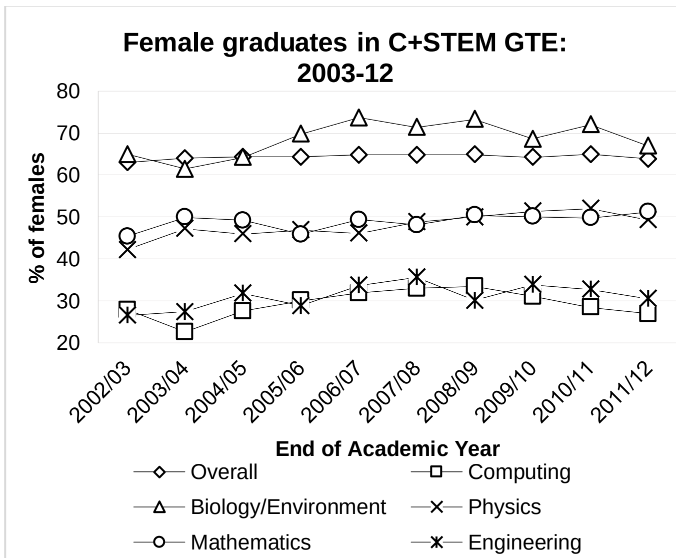


Figure 13. Female graduates representation in C+STEM GTE: 2003–12

Master degree studies: Figure 14 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 degrees awarded in the rest of the STEM disciplines fluctuated, but over the decade as a whole there was a general upward trend.

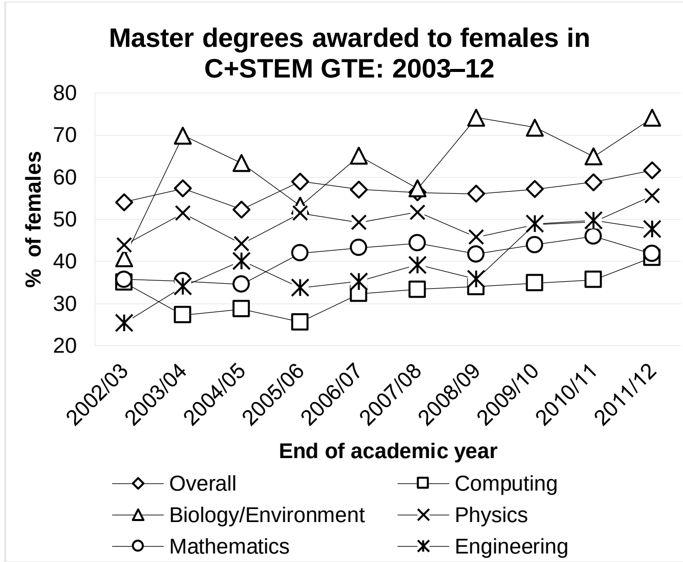


Figure 14. Female master degree graduates in C+STEM GTE: 2003–12

PhDs: Figure 15 shows 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.

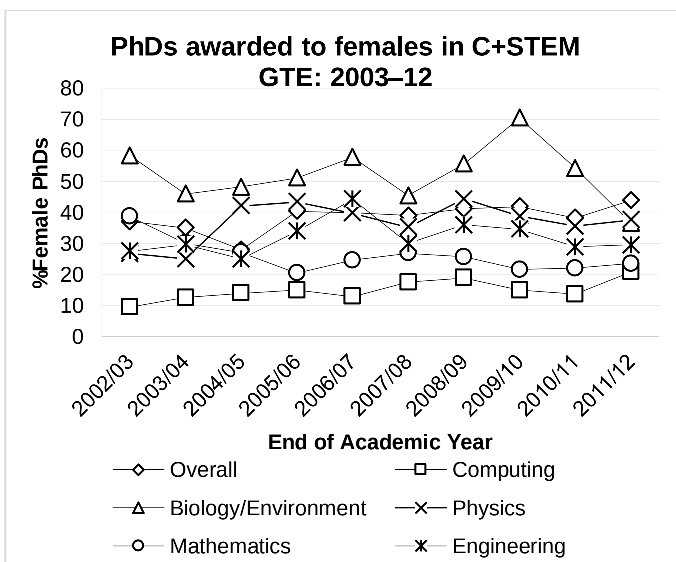


Figure 15. Female PhD graduates in C+STEM GTE: 2003–12

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.

***Mean values of the decade: percentages and numbers*.** Figure 16 illustrates the mean values of the female representation for the decade under study, in C+STEM for different levels of study; namely: freshmen, graduates of undergraduate studies, master's degrees graduates, and PhD graduates. It seems that the mean percentages of females, for the studied decade, in *'Computing'* depts are the lowest of all STEM disciplines for all different level of study. Females are better represented in *'Bio/Env'* depts, the only STEM discipline that females are more than males in all levels of study. Regarding the rest STEM disciplines, females' percentages in *'Math'* and '*Phys'* depts are close to 50%, with an exception in PhD degrees that their percentages are low. Females' percentages in *'Eng'* depts are the second worst in C+STEM disciplines in all levels of study, apart from PhD degrees that they are better represented compared to females in *'Math'* depts.

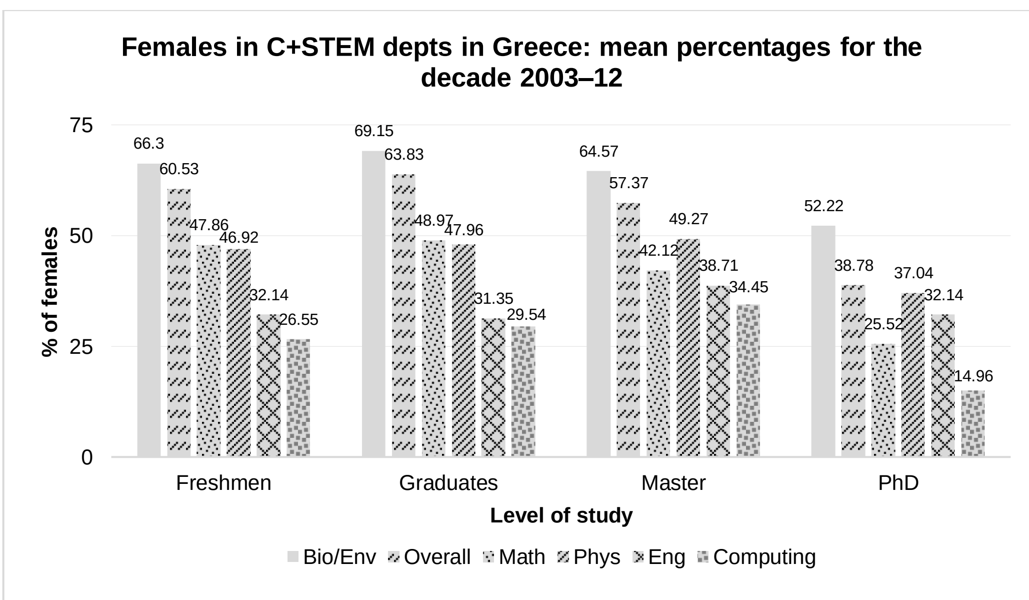


Figure 16. Percentages of females in C+STEM depts in Greece: mean values for the decade 2003–12

Figure 17 depicts the female representation, in terms of mean numbers, in C+STEM for the different levels of study. As is shown, 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'*. 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'* (see Figure 17) .

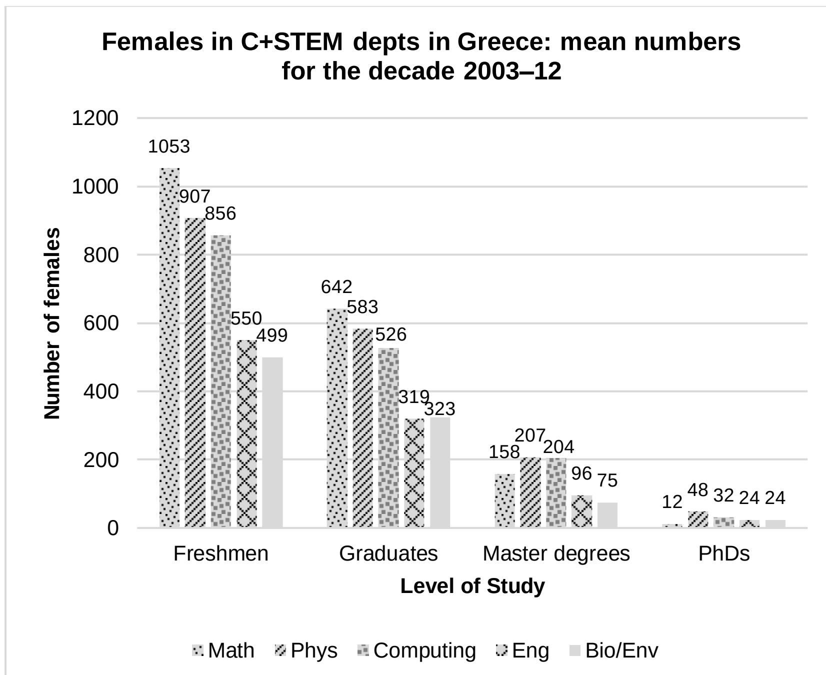


Figure 17. Number of females in C+STEM depts in Greece: mean values for the decade 2003–2012

5.2.3 Faculty Gender Representation in C+STEM Greek Tertiary Education

The results from the data analysis concern the 2003–12 (start of the academic year 2003/04 to the beginning of 2012/13) and are presented here in terms of: (a) faculty member gender representation in C+STEM Tertiary education in Greece, (b) comparison of female faculty member representation in Computing with that in the remaining fields of STEM education in Greece.

5.2.3.1 Gender representation of faculty members in C+STEM in Greek Tertiary education: 2003–2012

The gender representation of faculty members in Computing in Greek Tertiary education from 2003/04 to 2012/13 is presented here, in terms of faculty members: (a) in all Greek universities and engineering schools (Overall), and (b) in each of the Depts related to STEM education.

The total number (N) –male and female– and the percentage of female (F) faculty members in the decade 2003–12, as well as the number and the percentage of female (F%) Professors, Associate Professors, Assistant Professors and Lecturers during this period of time, are demonstrated in Table 6, Table 7, Table 8, Table 9, Table 10 and Table 11 with respect to all Greek: (a) Universities and Engineering Schools (*'Overall'*; Table 6), (b) *'Computing'* depts (in Table 7), (c) *'Bio/Env'* depts (in Table 8), (d) *'Phys'* depts (in Table 9), (e) *'Math'* depts (in Table 10), and (f) *'Eng'* depts (in Table 11).

Overall. As can be seen in Table 6, the total number of teaching staff in all Universities and Engineering Schools in Greece increased from 2003/04 to 2009/2010 and slightly decreased thereafter (see Table 6; column 2). The percentage of female staff remained more or less stable throughout the decade, fluctuating between 27.18% and 29.97%. (see Table 6; column 3). Each year of the decade there were, on average, 8,881 faculty members in all Greek University depts and Engineering schools while the percentage of female faculty members was, on average, 29.01% (SD=0.9).

As far as *professors* are concerned, as is shown in Table 6, their numbers increased throughout the decade, with a minor decrease in 2008/09 (see Table 6; column 4). The percentage of female professors increased from 2003/04 to 2009/2010 remaining at around 20% thereafter (see Table 6; column 5). That percentage varies from 13.60 to 20.22%. Each year on average, there were 2,551 professors (28.72% of the total number of faculty members in Greece), 18.15% (SD=2.14) of them female.

Regarding *associate professors*, their numbers increased between 2003/04 and 2006/07, but decreased thereafter (see Table 6; column 6). The percentage of female associate professors overall varied from 26.70% to 31.08% (see Table 6; column 7). Each year on average, there were 2,050 associate professors (23.08% of the total number of faculty members) in all Greek universities, while the percentage of their female counterparts was shown to be 28.52% (SD=1.28).

Table 6

Total number of faculty members in Greek Tertiary Education and females as a percentage of all faculty (male and female): in total and by rank

Faculty member gender representation in GTE, 2003–2012: Overall										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	**7,354**	**27.18**	**2,103**	**13.60**	**1,697**	**27.22**	**1,998**	34.68	1,556	39.33
2004/05	8,053	27.65	2,202	14.85	1,965	27.48	2,161	**31.2**	1,725	39.48
2005/06	8,237	28.19	2,241	16.47	1,981	26.70	2,223	31.85	1,792	39.96
2006/07	9,268	29.01	2,457	17.62	**2,200**	28.00	2,546	32.33	**2,065**	39.56
2007/08	9,326	29.29	2,619	18.86	2,153	28.19	2,701	32.51	1,853	**40.64**
2008/09	9,248	29.30	2,581	19.29	2,160	27.92	2,706	32.59	1,801	40.37
2009/10	**9,515**	**29.97**	2,816	19.46	2,149	**31.08**	2,886	33.68	1,664	39.90
2010/11	9,409	29.48	2,836	19.11	2,125	28.89	2,908	34.87	1,540	39.22
2011/12	9,306	29.63	**2,879**	**20.22**	2,036	29.32	**2,909**	35.27	1,482	37.25
2012/13	9,098	29.80	2,779	19.86	2,037	30.00	2,847	**35.62**	**1,435**	**37.21**
Average	8,881	M=29.01 SD=0.9	2,551	M=18.15 SD=2.14	2,050	M=28.52 SD=1.28	2,589	M=33.57 SD=1.49	1,691	M=39.38 SD=1.12

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

In terms of *assistant professors*, their numbers overall increased from 2003/04 to 2011/12, with a slight decrease in the following year (see Table 6; column 8). The percentage of female assistant professors experienced an increase over the decade, (see Table 6; column 9) fluctuating between 31.2% and 35.62. Surprisingly, in 2003/04, where the total number of assistant professors was shown to be 1,998 (the lowest in the decade), females claimed a high percentage of representation: 34.68%. Each year on average, there were 2,589 assistant professors (29.15% of the total number of faculty members), 33.57% (SD=1.49) of them female.

As far as *lecturers* are concerned, their numbers saw an overall increase from 2003/04 to 2006/07 but these decreased thereafter (see Table 6; column 10). The percentage of female lecturers, overall, varied from 37.21% to 40.64% (see Table 6; column 11). Each year on average, there were 1,691 lecturers (constituting 19.04% of the total number of faculty members overall), 39.38% (SD=1.12) of them female.

To sum up, each year of the decade on average, assistant professors (2,589) outnumbered professors (2,551), associate professors (2,050) and lecturers (1,691). Female assistant professors (869) outnumbered female lecturers (673), female associate professors (584) and female professors (463). Despite this fact, among the four ranks, females were better represented in the position of lecturers, followed by assistant professors, associate professors and professors (39.38%, compared to 33.57%, 28.52% and 18.15% respectively). It is also worth noting that, for each year of the decade, the percentage of female lecturers was higher overall than the respective numbers of professors, associate professors and assistant professors. It would seem that females were better represented as we move down towards the lower ranks.

Computing. The number of faculty members in *'Computing'* depts increased considerably from 2003/04 to 2009/2010 and thereafter remained stable, with a slight decrease (see Table 7; column 2). The percentage of female faculty members varied from 9.66% to 11.72% with minor fluctuations throughout the decade (see Table 7; column 3). Each year of the decade, on average, there were 553 faculty members, while the representation of females averaged 11.11% (SD=0.68).

Regarding *professors*, their numbers increased during the decade under study from 2004/05 to 2011/2012 (see Table 7; column 4). The percentage of female professors varied from 2.72% to 7.79% (see Table 7; column 5). It is worthy of mention that, even though the total number of professors increased, the percentage of females remained stable or slightly decreased. Each year on average, there were 224 professors in total, with only 6.34% (SD=1.82) of these being female. Professors in *'Computing'* depts comprised, each year on average, 40.50% of the total number of *'Computing'* faculty members and 8.78% of professors *'Overall'*.

In terms of *associate professors*, numbers remained more or less stable throughout the decade, with minor fluctuations. The percentage of female associate professors varied from 8.33% to 16.10 (see Table 7; column 7). Each year on average, there were 113 associate professors, 12.54% (SD=2.47) of these female. Associate professors in *'Computing'* depts constituted, on average, 20.43% of the total number of faculty members in these depts and 5.51% of the number of associate professors *'Overall'*.

Table 7

Total number of faculty members in Computing Depts and females as a percentage of all faculty (male and female): in total and by rank

Faculty member gender representation in GTE, 2003–2012: Computing										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	**461**	10.41	184	**2.72**	118	15.25	**99**	14.14	**60**	18.33
2004/05	466	10.52	**181**	3.87	118	**16.10**	101	11.88	66	16.67
2005/06	497	**9.66**	190	4.21	**128**	14.06	105	**10.48**	74	14.86
2006/07	523	10.52	212	5.19	117	12.82	110	18.18	84	**10.71**
2007/08	570	11.23	231	**7.79**	108	12.96	138	11.59	**93**	17.20
2008/09	567	11.46	226	7.52	104	14.42	149	12.08	90	16.67
2009/10	**615**	11.71	252	7.54	113	8.85	164	15.24	86	**20.93**
2010/11	612	11.60	253	7.51	108	**8.33**	177	**15.82**	74	20.27
2011/12	613	11.58	**258**	7.36	108	11.11	**181**	15.47	66	18.18
2012/13	605	**11.72**	253	7.51	**107**	11.22	177	15.25	68	19.12
Average	553	M=11.11 SD=0.68	224	M=6.34 SD=1.82	113	M=12.54 SD=2.47	140	M=14.20 SD=1.49	76	M=17.21 SD=1.12

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

The number of *assistant professors* increased from 2003/04 to 2012/13 and slightly decreased the following year (see Table 7; column 8). The percentage of female assistant professors varied from 11.59% to 18.18%. This percentage continuously decreased from 2003/04 to 2005/06, fluctuated for the following 3 years and remained at around 15% in the last 4 years of the decade (see Table 7; column 9). Each year on average, there were 140 assistant professors, 14.20% (SD=2.29) of them female. Assistant professors in *'Computing'* depts constituted 25.32% of the total number of faculty members in these depts and 5.41% of the number of assistant professors *'Overall'*.

In terms of *lecturers*, their numbers increased from 2003/04 to 2007/08, subsequently decreasing over the following 4 years (see Table 7; column 10). The percentage of female lecturers varied from 10.71% to 20.93% (see column 11). This percentage did not demonstrate any steady (upward or downward) trend. Each year on average, there were 76 lecturers in total, 17.21% (SD=2.78) of them female. Lecturers in *'Computing'* depts comprised 13.74% of the total number of faculty members in these depts and 4.67% of the number of lecturers *'Overall'*.

To sum up, for each year of the decade on average, professors (224) outnumbered assistant professors (140), associate professors (113) and lecturers (76) in Greek *'Computing'* depts. On the other hand, on average, there were more female assistant professors (19) than female professors (14) female associate professors (14) and female lecturers (13). However, the percentage of female professors in *'Computing'* depts is shown to be lower than the percentage of female associate professors and that of assistant professors both for each year of the decade and on average. The percentages of female lecturers in *'Computing'* depts were higher than – for each year of the decade – the respective percentages of professors and associate professors and – for each year, apart from one – the respective percentages of assistant professors. It would appear that, among the four ranks, females were best represented in the position of lecturers, followed by assistant professors, associate professors and professors (17.21% compared to 14.20%, 12.54% and 6.34% respectively). Finally, it should be noted that, over the whole decade, there were 2 depts that had no female faculty members whatsoever.

Bio/Env. There were even fewer faculty members in *'Bio/Env'* depts than in Computing depts. Taking into account the data presented in Table 8 (column 2), one can see that the total number of faculty members in *'Bio/Env'* depts remained stable, without considerable fluctuation, throughout the decade (see Table 8; column 2). The percentage of females varied from 38.86% to 41.44% (see Table 8; column 3). Each year on average, there were 219 faculty members in *'Bio/Env'* depts, while female representation was, on average, 39.83% (SD=0.93).

Each year on average, there were 61 *professors* in *'Bio/Env'* depts (see Table 8; column 4) comprising 27.85% of the total number of faculty members in these depts, while the percentage of female professors in those depts varied from 19.64% to 27.42%, averaging 23.78% (SD=2.57) (see Table 8; see column 5). Professors in *'Bio/Env'* depts constituted a mere 2.39% of the total number of professors *'Overall'*.

Table 8

Total number of faculty members in Bio/Env Depts and females as a percentage of all faculty (male and female): in total and by rank

Faculty member gender representation in GTE, 2003–2012: Bio/Env										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	214	39.25	56	**19.64**	65	36.92	**50**	44.00	43	62.79
2004/05	220	39.09	56	21.43	**70**	35.71	51	41.18	43	**65.12**
2005/06	**229**	39.30	57	21.05	68	**39.71**	50	**40.00**	**54**	57.41
2006/07	222	**41.44**	54	24.07	64	37.50	60	45.00	44	63.64
2007/08	220	40.91	**52**	26.92	65	36.92	62	43.55	41	60.98
2008/09	219	41.10	62	**27.42**	65	35.38	57	**54.39**	35	54.29
2009/10	227	40.09	72	26.39	57	**35.09**	**67**	50.75	31	58.06
2010/11	211	**38.86**	65	21.54	61	37.70	55	50.91	30	56.67
2011/12	215	39.07	67	23.88	56	37.50	64	50.00	28	53.57
2012/13	**210**	39.05	**73**	24.66	**51**	39.22	61	50.82	**25**	**52.00**
Average	219	M=39.83 SD=0.93	61	M=23.78 SD=2.57	62	M=37.14 SD=1.45	58	M=47.31 SD=4.64	37	M=59.09 SD=4.29

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

As far as *assistant professors* are concerned, there were, each year on average, 58 of these (see Table 8; column 8) while the percentage of female assistant professors varied from 41.18% to 54.39%, averaging 47.31% (SD=4.64) (see Table 8; column 9). It is worthy of mention that, over the last 5 years of the decade, female assistant professors in *'Bio/Env'* outnumbered their male counterparts. Assistant professors in *'Bio/Env'* depts constituted 26.48% of the faculty members in these depts and 2.24% of assistant professors *'Overall'*.

Regarding *lecturers*, each year on average there were 37 of these, while the percentage of females varied from 52% to 65.12%, averaging 59.09% (SD=4,29) (see Table 8; column 11). Notably, there were more female than male lecturers in *'Bio/Env'* depts for every single year of the decade. Lecturers in *'Bio/Env'* depts constituted 16.89% of the faculty members in these depts and 2.19% of lecturers *'Overall'*.

To sum up, each year of the decade on average, in *'Bio/Env'* depts, associate professors (62) outnumbered professors (61), assistant professors (58) and lecturers (37). Female assistant professors (27) outnumbered associate professors (23), lecturers (22) and professors (15). There were more female than male lecturers for every single year of the decade, while among the remaining three ranks, females were better represented in the position of assistant professors, followed respectively by associate professors and professors (47.31% compared to 37.41% and 23.78% respectively).

Phys. Taking into account the data presented in Table 9 (column 2), there was a noticeable reduction in the total number of the faculty members from 2004/05 to 2012/13, but nevertheless there were more faculty members than in *'Computing'* and *'Bio/Env'* depts. Despite this, the percentage of female faculty remained stable, at over 20%, with slight fluctuations over the decade, varying from 19.68% to 21.42% (see Table 9; column 3). Each year on average, there were 776 faculty members in *'Phys'* depts while the percentage of females averaged 20.67% (SD=0.5).

The percentage of female *professors* in *'Phys'* depts varied from 7.32% to 14.66% with an upwards trend throughout the decade. Each year on average, there were 221 professors (see Table 9; column 4) in *'Phys'* depts, the percentage of females being 10.62% (SD=2.47) (see Table 4; column 5). Professors in *'Phys'* depts comprised 28.48% of the total faculty members in these depts and 8.66% of professors *'Overall'*.

Regarding *associate professors*, each year on average, these were –at 222– almost as well represented as professors, while the percentage of female associate professors varied from 18.78% to 22.43%, averaging 21.49% (SD=1.83) (see Table 9; column 7). Associate professors in *'Phys'* depts constituted 28.60% of the total faculty members in these depts and 10.83% of the associate professors *'Overall'*.

Concerning *assistant professors*, each year on average, these numbered 235, while the percentage of females varied from 23.33% to 28.85%, averaging 26.18% (SD=2) (see Table 9; column 9). Assistant professors constituted 30.28% of the total faculty members in these depts and 9.08% of assistant professors *'Overall'* (2,589).

Table 9

Total number of faculty members in Physics Depts and females as a percentage of all faculty (male and female): in total and by rank

Faculty member gender representation in GTE, 2003–2012: 'Phys'										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	813	**19.68**	**205**	**7.32**	229	**18.78**	260	28.85	119	**22.69**
2004/05	**840**	20.24	207	7.73	**232**	20.26	**274**	27.37	**125**	24.80
2005/06	815	20.37	209	8.61	226	19.47	264	28.03	116	25.86
2006/07	809	20.64	210	9.05	232	20.69	253	**28.46**	114	24.56
2007/08	803	**21.42**	216	9.26	226	24.34	245	26.53	116	27.59
2008/09	785	21.27	225	9.78	222	**24.77**	240	23.33	98	34.69
2009/10	774	21.06	238	12.18	222	21.62	227	24.67	87	34.48
2010/11	739	20.43	**241**	12.45	218	21.56	208	25.00	72	30.56
2011/12	703	21.05	230	13.91	214	22.43	195	**23.59**	64	34.38
2012/13	**679**	20.62	232	**14.66**	**199**	21.11	**183**	24.04	65	30.77
Average	776	M=20.67 SD=0.5	221	M=10.62 SD=2.47	222	M=21.49 SD=1.83	235	M=26.18 SD=2	98	M=28.28 SD=4.31

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

In terms of *lecturers*, each year on average these numbered 98, while the percentage of female lecturers in *'Phys'* depts varied from 22.69% to 34.69%, averaging 28.28% (SD=4.31) (see Table 9; column 11). Lecturers in *'Phys'* depts constituted 12.63% of the total faculty members in these depts and 5.80% of lecturers 'overall' (1,691).

To sum up, in *'Phys'* depts, each year on average, there were more assistant professors (235) than associate professors (222), professors (221) and lecturers (98). Female assistant professors (62) outnumbered associate professors (48), lecturers (28) and professors (23). However, it seems that, among the four ranks, females were best represented in the position of lecturers, followed by assistant professors, associate professors and professors (28.28% compared to 26.18%, 21.49% and 10.62% respectively).

Math. The number of faculty members in *'Math'* depts increased from 2003/04 to 2008/09, remained stable the following year and then decreased over the following 2 years (see Table 10; column 2). The percentage of females varied from 15.97% to 18% (see Table 10; column 3). Each year on average, there were 422 faculty members in *'Math'* depts, while the percentage of females was, on average, 17.01% (SD=0.55).

Each year on average, there were 128 *professors* in *'Math'* depts (see Table 10; column 4) constituting 30.33% of the total faculty members in *'Math'* depts, while the percentage of female professors in these depts varied from 6.19% to 9.60%, averaging 8.52% (SD=1.06) (see Table 10; column 5). Professors in *'Math'* depts constituted just 5.02% of professors *'Overall'*.

Associate professors in *'Math'* depts outnumbered professors for the first 4 years of the decade but were fewer thereafter (see Table 10; column 6). On average, there were 114 assistant professors in *'Math'* depts, fewer than the number of professors, while the percentage of female associate professors varied from 11.90% to 19.80%, averaging 14.67% (SD=3.1) (see Table 10; column 7). Associate professors in *'Math'* depts comprised 27.01% of the total faculty members in these depts and 5.56% of associate professors *'Overall'*.

Assistant professors in *'Math'* depts averaged, each year, 133 faculty members, more than the average number of professors and associate professors (see Table 10;

columns, 3, 5 and 8). The percentage of female assistant professors in *'Math'* depts varied from 21.13% to 25.42%, averaging 23.55% (SD=1.33) (see Table 10; column 9). Assistant professors in *'Math'* depts constituted 31.52% of the faculty members in these depts and 5.14% of assistant professors 'overall' (2,589).

Table 10

Total number of faculty members in Mathematics Depts and females as a percentage of all faculty (male and female): in total and by rank

Female faculty member representation in GTE, 2003–2012: 'Math'										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	413	16.71	**113**	**6.19**	**126**	**11.90**	**118**	**25.42**	56	30.36
2004/05	428	17.52	119	6.72	120	12.50	126	23.81	**63**	**34.92**
2005/06	425	16.94	114	8.7	**126**	**11.90**	123	23.58	62	29.03
2006/07	428	16.59	114	8.77	121	12.40	130	23.08	**63**	25.40
2007/08	438	17.35	125	**9.60**	117	11.97	140	25.00	56	26.79
2008/09	**439**	17.08	129	9.30	112	14.29	**147**	23.81	51	23.53
2009/10	**439**	**18.00**	138	8.70	113	17.70	146	23.97	42	28.57
2010/11	418	17.22	**143**	9.09	101	**19.80**	142	**21.13**	32	28.13
2011/12	406	16.50	**143**	9.09	103	19.42	131	21.37	29	20.69
2012/13	**382**	**15.97**	141	8.51	**99**	17.17	122	24.59	**20**	**10.00**
Average	422	M=17.01 SD=0.55	128	M=8.52 SD=1.06	114	M=14.67 SD=3.1	133	M=23.55 SD=1.33	47	M=27.22 SD=6.4

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

The number of *lecturers* in *'Math'* depts was lower than the number of professors, associate professors and assistant professors for every single year of the decade (see Table 10; column 10). Each year on average, the number of lecturers in *'Math'* depts was 47, while the percentage of female lecturers varied from 10% to 34.92%, averaging 27.22 (SD= 6.4) (see Table 10; column 11). There is a noticeable decrease in the percentage of female lecturers in *'Math'* for the last year of the decade, while the same years the number of lecturers in general also decreased. Lecturers in *'Math'* depts constituted 11.14% of the faculty members in these depts and 2.78% of lecturers 'overall' (1,691).

To *sum up*, each year on average, in *'Math'* depts the assistant professors (133) outnumbered professors (128), associate professors (114) and lecturers (47). There were more female assistant professors (31) than associate professors (17), lecturers (13) and professors (11). Nevertheless, it seems that, among the four ranks, females were best represented in the position of lecturers, followed by assistant professors, associate professors and professors (27.22% compared to 23.55%, 16.47% and 8.52% respectively).

Eng: The number of faculty members in *'Eng'* depts increased slightly from 2003/04 to 2007/08 and remained more or less stable thereafter (see Table 11; column 2).

Table 11

Total number of faculty members in Engineering Depts and females as a percentage of all faculty (male and female): in total and by rank

Female faculty member representation in GTE, 2003–2012: 'Eng'										
Start of Academic Year	Total Faculty		Professors		Associate Professors		Assistant Professors		Lecturers	
	N	F%	N	F%	N	F%	N	F%	N	F%
2003/04	424	14.52	138	3.62	115	24.35	105	17.14	66	15.15
2004/05	450	14.94	157	8.28	109	17.43	107	19.63	77	10.39
2005/06	452	14.88	165	10.30	104	18.27	105	18.10	78	15.38
2006/07	464	14.85	158	8.86	111	18.02	113	16.81	82	15.85
2007/08	484	14.67	171	10.53	110	16.36	119	15.13	84	25.00
2008/09	484	15.50	190	14.21	108	10.19	120	15.00	66	22.73
2009/10	485	14.22	197	13.20	102	15.69	125	12.00	61	24.59
2010/11	484	15.49	200	11.50	108	16.67	120	12.50	56	28.57
2011/12	482	13.56	193	11.40	105	16.19	122	14.75	62	24.19
2012/13	482	14.39	199	10.05	109	16.51	113	17.70	61	19.67
Average	469	M=14.71 SD=0.55	177	M=10.46 SD=2.78	108	M=17.02 SD=3.26	115	M=15.75 SD=2.32	69	M=19.77 SD=5.47

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

The percentage of females in the faculty varied from 13.56% in 2011/12 to 15.49% in 2010/11 (see column 3). Each year on average, there were 469 faculty members in *'Eng'* schools, the percentage of females averaging 14.71% (SD=0.55).

Each year on average, there were 177 *professors*, while the percentage of female professors varied from 3.62% to 14.21%, averaging 10.46% (SD=2.78) (see Table 11; column 5). Professors in *'Eng'* depts constituted 37.74% of the total faculty members in these depts and 6.94%, of professors 'overall' (2,551).

Each year on average, there were 108 *associate professors*, while the percentage of female associate professors varied from 15.69% to 24.35%, averaging 17.02% (SD=3.26) (see Table 11; column 7). Associate professors in *'Eng'* depts constituted 23.03% of the total faculty members in these depts and 5.27% of associate professors *'Overall'*.

Each year on average, there were 115 *assistant professors* in *'Eng'* depts, while the percentage of female assistant professors over the decade varied from 12% to 19.63%, averaging 15.75% (SD=2.32) (see Table 11; column 9). Assistant professors in *'Eng'* depts constituted 24.52% of the total faculty members in these depts and 4.44% of assistant professors *'Overall'*.

Each year on average, there were 69 *lecturers* in *'Eng'* depts, the percentage of female lecturers varying from 10.39% to 28.57%, averaging 19.77% (SD=5.47) (see Table 11; column 11). Lecturers in *'Eng'* depts constituted 14.71% of the total faculty members in these depts and 4.08% of lecturers *'Overall'*.

To sum up, in *'Eng'* depts, each year on average, professors (177) outnumbered assistant professors (115), associate professors (108) and lecturers (69). There were more female professors (19) than assistant professors (18), associate professors (18) and lecturers (14). Here, females were best represented in the position of lecturers, followed by assistant professors, associate professors and professors (19.77% compared to 17.02%, 15.75% and 10.46% respectively). It is worth noting that, for every single year of the decade, in *'Eng'* depts: (a) lecturers were outnumbered by professors, associate professors and assistant professors, (b) assistant professors were less prevalent than professors but greater in number than associate professors over the last 8 years of the decade, (c) associate professors were considerably fewer in number than professors (see Table 11; columns, 4, 6, 8 and 10).

5.2.3.2 Comparison of female faculty members' representation in C+STEM education in Greece: trends and mean values

***Trends*.** Figure 18 to Figure 21 diagrammatically display the trends –in terms of percentages– of female faculty representation in *'Computing'*, *'Bio/Env'*, *'Phys'*, *'Math'*, *'Eng'* and *'Overall'* from 2003/04 through 2012/13 for different ranks, namely: Professors (Figure 18), Associate Professors (Figure 19), Assistant Professors (Figure 20), and Lecturers (Figure 21).

*Professors***.** As shown in Figure 18, the percentage of female professors during the decade under study: (a) *'Overall'* demonstrates an upward trend ending at around 20%, (b) in *'Bio/Env'* depts was greater each year than the respective percentages in every other discipline, demonstrating an upward trend that reached just over 27% in 2008/09, (c) in *'Phys'* depts demonstrated an upward trend, reaching close to 15% at the end of the decade, greater than that for *'Computing'* and *'Math'* each year (d) in *'Math'* depts appeared as a stable trend at under 10% each year and lower than that for *'Eng'* for most years and greater than that for *'Computing'* each year (e) in *'Eng'* demonstrated an upward trend until 2008/09 and then decreased, reaching just over 10% in 2012/13, clearly greater than that for *'Computing'* in any year (f) in *'Computing'* depts demonstrated an upward trend until 2007/08, thereafter stabilizing without ever exceeding 10%. On the whole, female professors were best represented in *'Bio/Env'*, and worst in *'Computing'*.

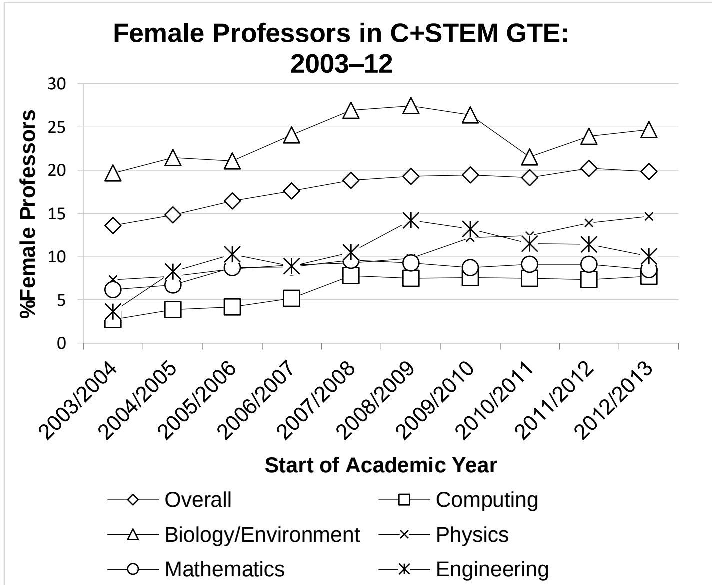


Figure 18. Female professors in C+STEM Greek Tertiary Education: 2003–12

Associate professors. As illustrated in Figure 19, the percentage of female associate professors during the said decade: (a) *'Overall'* demonstrated a steady trend, with minor fluctuations, reaching 30% at the end of the decade (b) in *'Bio/Env'* depts fluctuated slightly between 35% and 40%, higher than the respective percentages of studied disciplines each year (c) in *'Phys'* depts demonstrated an upward trend up to 2008/09, subsequently remaining at over 20%, greater than that of *'Math'*, *'Eng'* and *'Computing'* for each year of the decade with the exception of the very first (c) in *'Math'* depts remained stable until 2007/2008 and increased thereafter, reaching almost 20%. Female associate professors in *'Math'* are worst represented compared to *'Eng'*, and *'Computing'* during the first 5 years of the decade and better thereafter (d) in *'Eng'* depts, started at 25% and followed a downward trend until 2008/2009, then demonstrating an upward trend, remaining greater than that for *'Computing'* for most of the years (e) in *'Computing'* depts, started at 15% and followed a downward trend ending in just over 11% in 2012/13, being worst represented during the last 4 years of the decade.

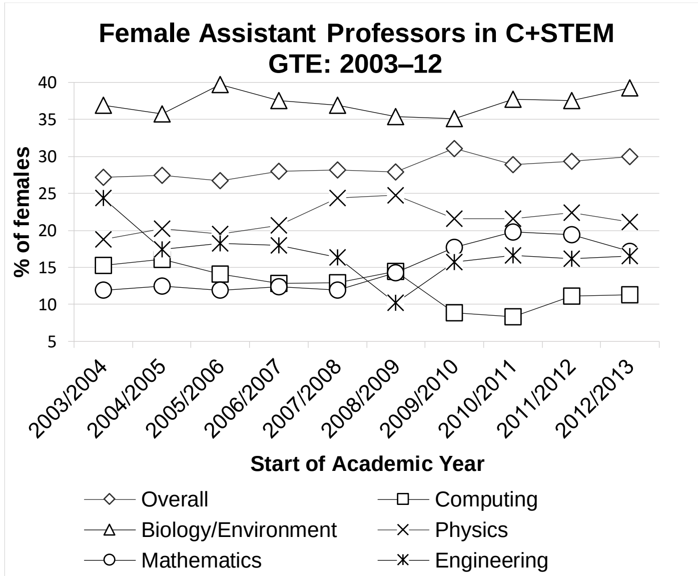


Figure 19. Female associate professors in C+STEM GTE: 2003–12

Assistant professors. As depicted in Figure 20, the percentage of female assistant professors during the decade under study: (a) overall remained steadily over 30%, with an upward trend observed during the last 9 years. (b) in *'Bio/Env'* depts each year remained over 40%, exceeding 54% in the last 5 years, higher than the respective percentages in every other discipline (c) in *'Phys'* depts demonstrated a downward trend during the decade, starting at around 29% and ending at approximately 24%, higher than that for *'Math'*, *'Eng'* and *'Computing'* each year (d) in *'Math'* depts, with minor fluctuations, started and finished the decade at around 25%, clearly higher than that for *'Eng'* and *'Computing'* each year (e) in *'Eng'*, demonstrated a downward trend until 2009/10 and then a slight increase over the next 3 years, remaining under 20% but higher than that for *'Computing'* for most of the years (f) in *'Computing'* depts remained under 20% each year, with some fluctuation and demonstrating relative stability over the last 6 years. Among the five studied disciplines of STEM, female assistant professors are clearly less well represented in both *'Eng'* and *'Computing'*.

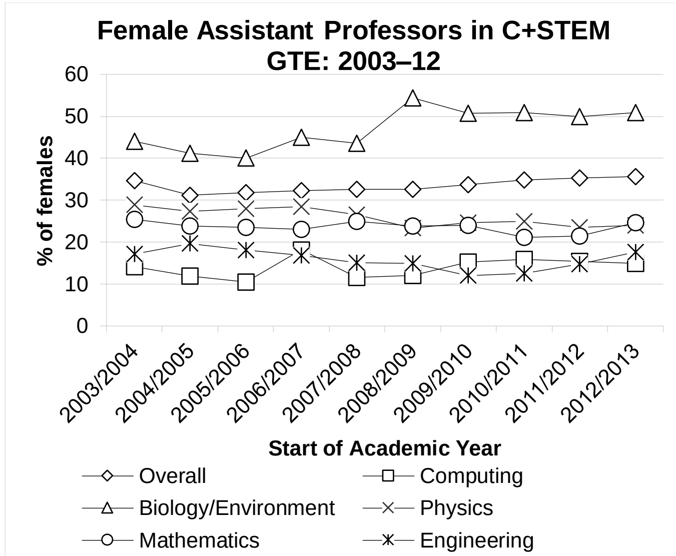


Figure 20. Percentage of female assistant professors in C+STEM GTE: 2003–12

Lecturers: As demonstrated in Figure 21, the percentage of female lecturers during the decade: (a) *'Overall'* remained steady, at around 40%; (b) in *'Bio/Env'* depts demonstrated a downward trend at over 50% each year and clearly higher than the respective percentages in other disciplines; (c) in *'Phys'* depts, demonstrated an upward trend remaining higher than that of *'Eng'* and *'Computing'* each year; (d) in *'Math'* depts demonstrated a downward trend remaining higher than that for *'Eng'* and *'Computing'* in the first 7 years and ending lower than the figures for these disciplines in the last year; (e) in *'Eng'*, demonstrated an upward trend up to 2010/11, reaching just under 29%, and decreasing over the following 2 years, ending at about 20%, higher than the respective figures in *'Computing'* for the last 8 years; (f) in *'Computing'* depts decreased during the first 3 years, reaching just over 10%, but subsequently increasing and stabilizing at just under 20%. Among the five disciplines, female lecturers are less well represented in *'Computing'* depts for most of the years of the decade.

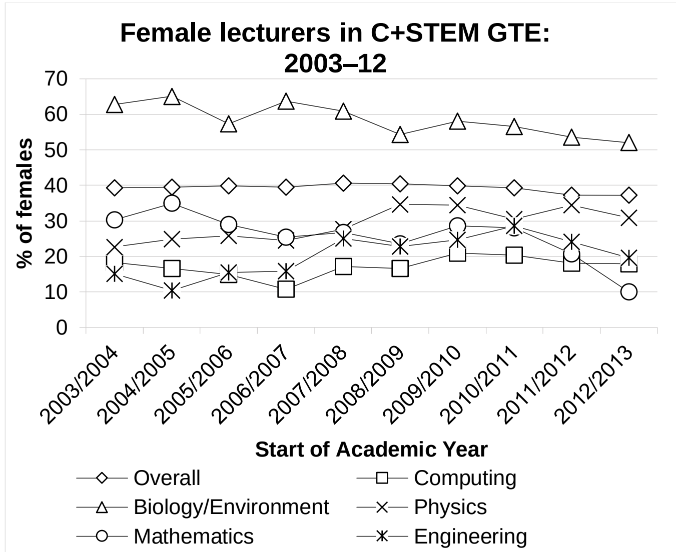


Figure 21. Percentage of female lecturers in C+STEM GTE: 2003–12

As can be seen from Figure 18, Figure 19, Figure 20 and Figure 21, among the studied disciplines included in STEM fields, females were better represented, in every rank, in *'Bio/Env'* depts. The corresponding female percentages *'Overall'* were, in every rank, the second highest, while the corresponding percentages of females in *'Computing'* in every rank were among the lowest.

Mean values of the decade: percentages and numbers. Figure 22 illustrates the mean values of the percentages of females in C+STEM, for the four different ranks of faculty members; namely: professors, associate professors, assistant professors and lecturers. It seems that females are worst represented in *'Computing'* depts as their mean percentages are the lowest of all STEM disciplines for all different ranks. Females are better represented in *'Bio/Env'* depts, the only STEM discipline that females are more than males in one rank: lecturers. Females' percentages in *'Eng'* depts are the second worst in C+STEM disciplines in all ranks, apart from Associate Professors that they are better represented compared to females in *'Math'* depts. It is remarkable though, that in C+STEM depts females are better represented in lower ranks; in each discipline, females' percentages in lectures are greater compared to assistant professors, which are greater than associate professors, which are greater than professors.

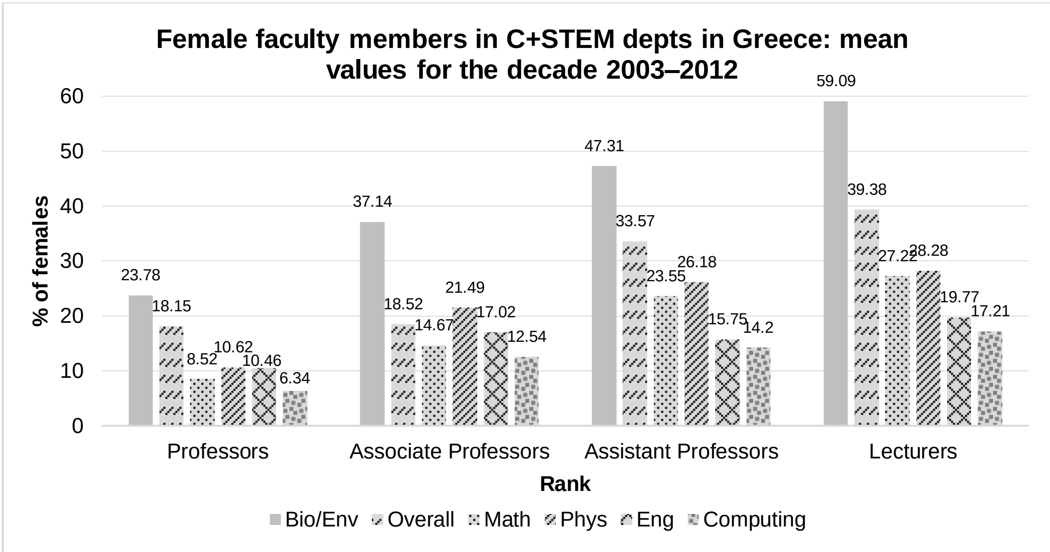


Figure 22. Percentages of female faculty members in C+STEM depts in Greece: mean values of the decade 2003–2012

Figure 23 depicts the average number of females in C+STEM for the different ranks of faculty members. As it is shown, on average, females in *'Phys'* depts in every rank outnumber females in *'Computing'* and the rest of STEM disciplines. Numerically, on average, female professors and assistant professors in *'Computing'* depts are second-to-last, while female associate professors and lecturers are last among STEM disciplines.

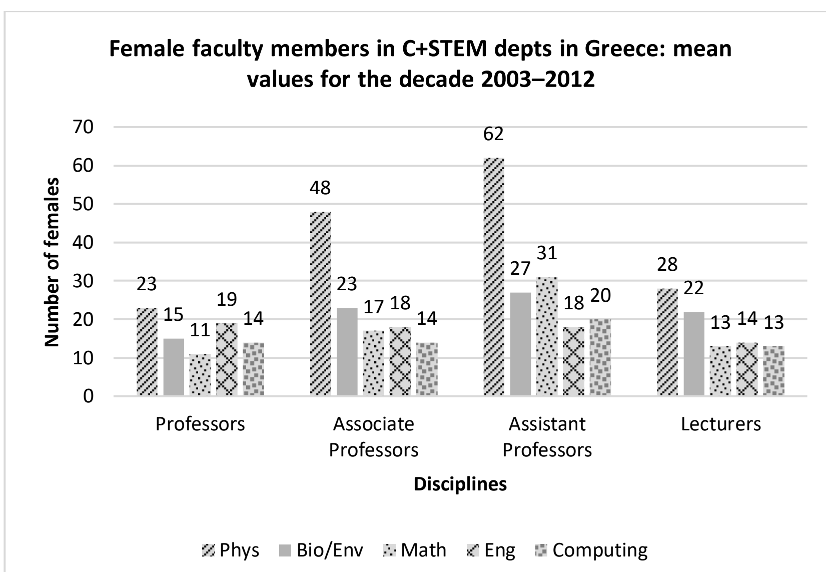


Figure 23. Number of female faculty in C+STEM depts in Greece: mean values of the decade 2003–12

5.3 Study1: Review of Main Research Findings

This section presents a review of the main findings of *Study1*.

5.3.1 Teacher Gender Representation in C+STEM Greek Secondary Education

The main research findings of the analysis of the data concerning the teacher gender representation in C+STEM GSE are presented in response to the research questions posed to approach sub-aim1.1.

5.3.1.1 Teacher gender representation in Computing and STEM (RQ.1.1.i). The data analysis revealed that, even though female teachers are more prevalent than male teachers in secondary education in Greece (‘*Overall’)*, there are fewer female teachers compared to males in *‘Computing’*. In fact, on average, during the studied decade, the percentage of female Computing teachers in Gymnasiums was almost 46%, fewer in GL (approximately 38%) and even fewer in VL (around 36%). The low representation of female teachers would seem to be an issue for the rest of the STEM disciplines as well. During the decade under study, there were constantly fewer female teachers in *‘Science’*, *‘Math’* and *‘Eng’* than their male counterparts in both levels of study in secondary education. It is worth mentioning though that female teachers, in Computing and the rest STEM studied disciplines, were better represented in Gymnasium, compared to GL and VL. Overall, it seems that females are underrepresented in the C+STEM GSE (Kordaki & Berdousis, 2017; Berdousis & Kordaki, 2013). This finding is in line with relevant studies in other countries (e.g. Camp, 2012; Hayes, 2011a; Hill et al., 2010) that support that females in the Computing workforce are less prevalent than males. It seems though, that regarding *‘Computing’* teacher workforce, things are not so bad for females, especially in Gymnasium. Teaching seems to be a way for professional rehabilitation for females in Computing.

5.3.1.2 Female teacher representation in Computing compared to the female teacher representation in related STEM disciplines (RQ.1.1.ii). 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. *‘Science’*, ‘*Math’* and *‘Eng’*, in Gymnasium, GL and VL. In that sense, it seems that things are good enough for females in *‘Computing’* teaching workforce compared to the rest of the STEM disciplines. Nevertheless, numerically, there were more female *'Science'* teachers than female *'Math'* teachers, and considerably more than female *'Computing'* teachers (Kordaki & Berdousis, 2017).

5.3.2 Student Gender Representation in C+STEM Greek Tertiary Education

The main research findings arising from the analysis of the data regarding the student representation, in terms of the participation of female freshmen, graduates, master's degree graduates and PhD graduates, in C+STEM GTE are presented here in the context of the research questions posed to meet sub-aim1.2.

5.3.2.1 Student gender representation in Computing and STEM (RQ.1.2.i).

The analysis of the data revealed that every single year of the decade under study: (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'* depts, (b) females were less prevalent than males at PhD level in *'Computing', 'Phys', 'Math', 'Eng'* depts, as well as *'Overall'*, (c) there were more females than males at all levels of study –except PhD in *'Bio/Env'* and *'Overall'*. On average, in *'Computing'* depts the percentage of female freshmen was 26.55%, of female graduates 29.54%, of female master degree graduates 34.45% and of female PhD degrees 14.96%. The average percentage of female students and graduates in *'Bio/Env'* depts was over 60% for freshmen, graduates of undergraduates and master degrees and over 52% for PhDs. Regarding the rest STEM disciplines, females' percentages in *'Math'* and '*Phys'* depts were close to 50%, with an exception in PhD degrees that their percentages are low. Females' average percentages in *'Eng'* depts were over 30% in all levels of study, ranging from 32% in PhD degrees to just below 39% in master degrees. Overall, the representation of females in all levels of study in C+STEM GSE seems to be at the same level of the female representation in other countries (Kordaki & Berdousis, 2017).

5.3.2.2 Female student representation in Computing compared to the female student representation in related STEM disciplines (RQ.1.2.ii). The percentages of female freshmen in *'Computing'* depts were lower than in any other STEM discipline. In fact, female freshmen were: (a) steadily more prevalent than male freshmen in *'Bio/Env'* depts, (b) close in number to that of male freshmen in *'Phys'* depts, in some years actually outnumbering them, (c) fewer than their male counterparts in *'Math'* depts 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'* depts. These results support previous research findings (Camp 2012; Gürer & Camp 2002) that indicate there are fewer females than males in STEM depts –with the exception of *'Bio/Env'*– and especially in *'Computing'*.

Regarding graduates of undergraduate programs, the percentages of female of *'Computing'* depts were, for most of the decade, the lowest of all STEM disciplines, yet with an upward trend throughout the decade. 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/Env'* depts. There is no clear predominance of male over female graduates in either *'Phys'* or *'Math'* depts, nor is there a clear trend for the percentages of female graduates from *'Eng'* depts. However, these percentages are equally as alarming as those for female graduates from *'Computing'* depts.

Similarly, the percentages of female graduates from master's degree programs from *'Computing'* depts were the lowest, almost every year of the decade, of 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 (*'Overall'*) as well as in *'Bio/Life'* depts, (b) close to or greater than the number of male graduates in *'Phys'* depts, (c) fewer than male graduates in *'Math'* and *'Eng'* depts.

Finally, the percentages of female graduates of PhDs in *'Computing'* depts were the lowest of all STEM disciplines. In fact, there were also fewer PhDs awarded to females in '*Phys', 'Math'* and *'Eng'* depts than those awarded to males, while only PhDs awarded to females in 'Bio/Env' depts were greater in number than those awarded to males.

On the whole, it seems that the mean percentages of females, for the studied decade, in *'Computing'* depts are the lowest of all STEM disciplines for all different level of study (Kordaki & Berdousis, 2017). Females are better represented in *'Bio/Env'* depts, while females' percentages in *'Math'* and '*Phys'* depts are close to 50%, with an exception in PhD degrees that their percentages are really low. Females' percentages in

'Eng' depts are the second worst in C+STEM disciplines in all levels of study, apart from PhD degrees that they are better represented compared to females in *'Math'* depts. Numerically, on average, female freshmen in *'Computing'* outnumber female freshmen in *'Bio/Env'* and *'Eng'* and remain relatively close in number in *'Phys'* and *'Math'*. 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'*.

5.3.3 Faculty Gender Representation in C+STEM Greek Tertiary Education

The results arising from the analysis of the data provide useful insights into the disciplines of C+STEM in GTE in terms of faculty member gender representation that would help to approach sub-aim1.3 of the thesis by answering the two research questions set.

5.3.3.1 Faculty gender representation in Computing and STEM (RQ.1.3.i). For every single year of the decade, females had less representation than males in C+STEM: (a) in the total number of faculty members in each discipline as well as *'Overall'*, (b) in each individual rank, except Bio/Env, where female lecturers outnumbered their male counterparts, and female assistant professors, where they outnumbered their male counterparts during the last 5 years of the decade (Berdousis & Kordaki, 2015).

Underrepresentation of female faculty members was accompanied by alarming low percentages for females, where individually in *'Computing', 'Eng', 'Math'* and *'Phys'* they did not exceed in any one year: (a) 15% for professors, (b) 25% for associate professors, (c) 30% for assistant professors and (d) 35% for lecturers.

The distribution of female faculty members in C+STEM by rank is a finding of this study that merits special attention. The different number of faculty members, the diverse distribution among their ranks and the quotas of females *'Overall'* and in C+STEM disciplines, emerge as different proportions among the ranks. In particular, on average, (a) *'Overall'*, assistant professors outnumbered professors, associate professors and lecturers, (b) in *'Computing'*, numbers of professors exceeded those of assistant professors, associate professors and lecturers, while female assistant professors outnumbered professors, associate professors and lecturers, (c) in *'Bio/Env'*, numbers of professors exceeded those of associate professors, assistant professors and lecturers while female assistant professors outnumbered associate professors, lecturers and professors, (d) in *'Phys'*, there were more assistant professors than associate professors, professors and lecturers while female assistant professors outnumbered associate professors, lecturers and professors, (e) in *'Math'*, numbers of assistant professors exceeded those of professors, associate professors and lecturers while there were more female assistant professors than associate professors, lecturers and professors, (f) in *'Eng'*, professors outnumbered assistant professors, associate professors and lecturers while numbers of female professors exceeded those of assistant professors, associate professors and lecturers.

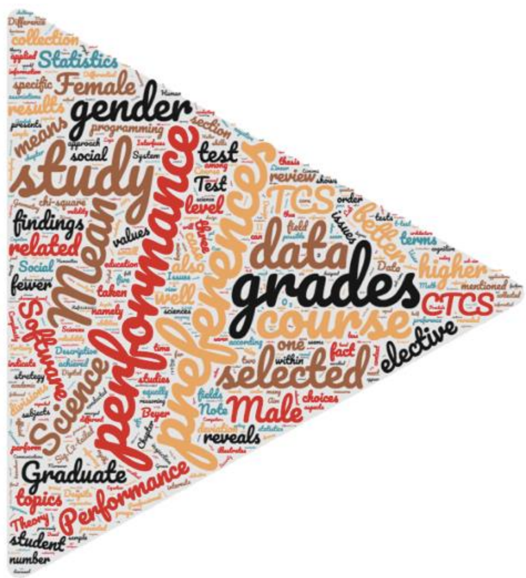
5.3.3.2 Female faculty representation in Computing compared to the female faculty representation in related STEM disciplines (RQ.1.3.ii). The percentages of female faculty members in *'Computing'* depts, in every rank, were the lowest among the STEM disciplines for all or most of the years in the decade under study, as: (a) professors, despite a upward trend through the decade, remained under 9%, (b) associate professors demonstrated a downward trend, without exceeding 16% in any one year, (c) assistant professors remained between 10% and 20%, as with Eng, while (d) lecturers reached just over 20%. It is also remarkable that, during the whole decade, there were two *'Computing'* depts that had no female faculty members whatsoever, while there were *'Computing'* depts where, even though there were female faculty members, some of the ranks had no female presence.

The results derived from the cross sectional analysis regarding the female faculty member representation among ranks in C+STEM highlight important findings: (a) female professors were better represented in *'Bio/Env'*, and worst represented in *'Computing'*, while in *'Phys'*, *'Eng'*, and *'Math'* their percentages demonstrated an upward trend until 2008/2009 and then, a stabilizing trend in *'Math'*, a continuous upward trend in *'Phys'* but downward in *'Eng'*, (b) female associate professors were best represented in *'Bio/Env'*, followed by *'Phys'*, while in *'Math'* they were worst represented when compared to *'Eng'*, and *'Computing'* for the first 5 years of the decade, and better thereafter. Female associate professors in *'Eng'* were better represented than in *'Computing'* for most of the years under study, but worst represented in the last 4 years of the decade (c) female assistant professors were best represented in *'Bio/Env'*, followed by *'Phys'* and *'Math'*, while in *'Computing'*, along with *'Eng'*, they were worst represented (d) female lecturers were better represented in *'Bio/Env'*, where females outnumbered males, followed by *'Math'* and *'Phys'* in the first half of the decade.

Comparing the number of faculty members in C+STEM fields, on average, there were more faculty members in *'Phys'* than in *'Computing'*, and subsequently in *'Eng', 'Math'* and *'Bio/Env'*. Despite the fact that faculty members in *'Computing'* were second most populous among the studied STEM fields, females were the least prevalent due to their discouragingly low percentages (Berdousis & Kordaki, 2018).

Chapter 6

Gender Differences in Preferences and Performance in Computer Science Education



Summary: The aim of this chapter is to thoroughly describe the context and the results of *'Study2: Gender differences in preferences and performance in Computer Science Education'* of this thesis. In addition, the focus of this analysis is directed towards responding to the research questions posed within the context of the second study.

6.1 Context of Study2

6.1.1 Aim of the Study

The aim of *'Study2'* (Aim 2 of the thesis) is to investigate gender differences regarding students preferences (sub-aim 2.1) and performance (sub-aim 2.2) in terms of CS undergraduate courses comprising the entire curriculum of a CS dept. For each of these sub-aims one research question was posed: RQ.2.1.i and RQ.2.2.i respectively (see chapter 4).

6.1.2 Methodological Choices

The research methodology of Study2 is presented in detail in the *'Research Methodology'* chapter of this thesis were the layers of the research onion are fully discussed. However, the techniques and procedures, in terms of data collection and data analysis, of Study2 are presented here in detail.

6.1.2.1 Data collection. Quantitative data were collected for the purpose of this study. Secondary data referring to the grades of the graduates in the compulsory and the elective CS courses they had selected from the curriculum in order to earn their graduate degree were collected from the official records of the DCS&T (see Table 1 in Appendix II). The data collected concerned 89 graduates of the deptartment. On the date of the collection of the data, these 89 graduates comprised the entirety of the graduates of the dept enrolled from 2002 to 2008. Of these 89 graduates, there were 69 males (N1=69; percentage 77,53%) and 20 females (N2=20; percentage 22,47%).

The secondary data collected referred to the grades of the graduates in the compulsory and elective courses. According to the curriculum of the DCS&T, in the academic period in question, students had to enroll and pass examinations in 21 compulsory courses as well as in 25 electives in order to earn a degree. For the purposes of the current study, in compliance with the curriculum of DCS&T, the courses were classified into 3 divisions, namely: *'Theoretical CS'* (TCS), *'Software Systems'* (SS), *'Computer Technology and Computer Systems'* (CTCS). The TCS division contained theoretical CS courses: 4 compulsory and 10 electives; The SS division featured software engineering courses: 8 compulsory and 27 electives; the CTCS division included mainly hardware-oriented courses: 3 compulsory and 14 electives. There were also two groups of courses: *'Math and Physics'* (M&P) consisting of 7 compulsory courses related to Math and Physics, and *'General Education'* (GE) which includes 21 electives covering social, ethical, law and humanities issues (see Tables 2 to 6 in Appendix II for a full list of the courses divided in divisions).

6.1.2.2 Data analysis. For each of the abovementioned divisions, tables for compulsory and elective courses were created, and grades of the male and female graduates were quantitatively-analyzed according to the aforementioned classification of courses. In order to analyze the data, statistical analysis (descriptive and inferential) was performed. To calculate the results, the Statistical Package for Social Sciences (SPSS) v.24.0 was used (see Figures 1 to 24 in Appendix II for a review of the *'variable'* and *'data view'* in SPPS). Regarding the performance of male and female graduates, mean grades and standard deviation values were calculated for each of the compulsory/elective courses. Independent sample t-tests were conducted to investigate whether these mean grades differed significantly according to gender (see Tables 7 to 14 in Appendix II for the detailed statistical analysis –group statistics and independent samples t test– of male and female graduates' performance in compulsory courses). As far as the preferences of males and females are concerned –in each of the elective courses– the percentage of graduates (males/females) who selected a course was estimated and the chi square test for independence (with Yates Continuity Correction) was performed to examine the extent to which gender is related to course selections (McHugh 2013). For this study, elective courses selected by fewer than 5 graduates (males or females), were not taken into consideration in the performance analysis. Nevertheless, these courses are highlighted in the results section as they are indicative of the preferences of male and female graduates (see Tables 15 to 22 in the Appendix II for a full review of the performance analysis in all the elective courses included in the curriculum of DCS&T). Based on the research literature, most gender differences are expected to fall within a small range. Of course, there is always variability. Even though a significant gender difference is found, this does not mean all males or females differ from each other. As is usual, all statements refer to average differences between groups, not differences among individuals.

6.2 Study2: Results

In this section, the results emerged from the data analysis are presented in subsections for each of the above-mentioned three divisions of courses, as well as for M&P compulsory courses and GE electives. For each of the aforementioned groups of courses, performance in compulsory and elective courses, as well as student preferences in electives are presented in the Tables. Specifically, the Tables referring to the performance in compulsory courses (Table 12, Table 14, Table 16, and Table 18) presents descriptive statistics –mean grades and standard deviation (SD) values– along with the independent samples t-test results for the equality of means. As far as the electives are concerned, similar Tables are generated regarding graduate performance, while for graduate preferences two more columns are added to present the percentage of graduates (males and females) who selected the corresponding elective (Table 13, Table 15, Table 17, and Table 19). Significant associations are presented in text providing chi square and p values.

6.2.1 Graduate Preferences and Performance in *'Theoretical CS'* (TCS) courses

6.2.1.1 TCS compulsory courses: graduate performance. Table 12 illustrates the mean grades for males and females in the four compulsory courses in TCS division.

Table 12

Performance in 'Theoretical CS' compulsory courses

Graduates' performance in 'Theoretical CS' compulsory courses							
	Group Statistics				Independent Samples Test		
	Male		Female		T test for equality of means		
Courses	Mean grade (I)	SD	Mean grade (J)	SD	t	Sig. (2-tailed)	Mean Difference (I-J)
Intro to S&T of Informatics[1]	7.80	1.26	7.25	1.77	1.555	0.123	0.547
Computational Science I	8.33	1.69	8.10	1.77	0.537	0.593	0.233
Algorithms and Complexity	6.75	1.27	6.85	1.16	0.327	0.745	-0.103
Theory of Computation	6.70	1.16	6.90	1.50	-0.646	0.579	-0.204

Note. 1-Introduction to Science and Technology of Informatics

Despite the fact that male graduates achieved higher grades in '*Intro to S&T of Informatics*', '*Computational Science*', and *'Algorithms & Complexity'* compared to females, and females performed slightly better in '*Theory of Computation*', the statistical analysis revealed that the differences in the mean grades are not statistically significant.

6.2.1.2 TCS electives: graduate preferences. An inspection of the number of graduates who selected each of the 10 electives in TCS division reveals that there were three elective courses that were selected by a very small number of female graduates (fewer than five). These courses are related to applied mathematics and theoretical CS (*'Operational Research'*), the study of mathematical structures (*'Graph Theory'*) and other advanced topics in TCS ('Advanced Topics in TCS'). These courses were also selected by fewer than 16 (25%) males (for a review of the statistical analysis of these courses see Tables 15 and 16 in Appendix II).

For the remaining seven elective courses, Table 13 illustrates the percentage of male and female graduates who selected the corresponding elective course, and the mean and standard deviation values of the grades of male and female graduates for each course.

Table 13

Preferences and performance in 'Theoretical CS' electives

Graduates' preferences and performance in *'Theoretical CS'* electives									
	Group Statistics						Independent Samples Test T test for equality of means		
	Preferences		Performance						
	Male	Female	Male		Female				
Courses	graduates who selected the course (%)		Mean grade (J)	SD	Mean grade (J)	SD	t	Sig (2-tailed)	Mean difference (I-J)
Combinational Optimization	91.30	90	8.31	1.34	8.44	1.28	-0.381	0.704	-0.13
Computational Geometry	36.23	60	8.06	1.39	7.88	1.54	0.365	0.717	0.18
Computational Science II	49.28	50	9.20	0.87	9.25	0.72	-0.146	0.885	-0.05
Parallel Algorithms	76.81	90	7.64	1.93	7.69	1.82	-0.102	0.919	-0.05
Computational Complexity	24.64	25	6.91	0.77	7.10	1.02	-0.445	0.661	-0.19
Fractals	27.54	35	7.68	1.31	8.14	1.49	-0.762	0.453	-0.46
Cryptography	14.49	40	6.60	1.50	7.50	1.07	-1.424	0.174	-0.90

At first glance, it seems that female graduates selected more electives (6) at a higher percentage compared to males. Nevertheless, the chi-square test for independence indicates that there are only three significant associations in favor of females in the following courses: (a) *'Computational Geometry'* [X_2 (1) = 3.606, p = 0.048], (b) *'Fractals'* [X_2 (1) = 3.562, p = 0.049], and (c) *'Cryptography'* [X_2 (1) = 6.253, p = 0.012].

6.2.1.3 TCS electives: graduate performance. Concerning the performance of male and female graduates in these seven TCS division electives, Table 13 reveals that according to the independent sample t-test that was conducted to compare the mean grades of male and female graduates, there was no statistically significant difference in the mean grade of the electives in the TCS division.

6.2.2 Graduate Preferences and Performance in '*System Software*' (SS) courses

6.2.2.1 SS compulsory courses: graduate performance. The performance of male and female graduates in SS compulsory courses is illustrated in Table 14.

Table 14

Performance in 'Software Systems' compulsory courses

Graduates' performance in *'Software Systems'* compulsory courses							
	Group Statistics				Independent Samples Test		
	Male		Female		T test for equality of means		
Courses	Mean grade (I)	SD	Mean grade (J)	SD	t	Sig. (2-tailed)	Mean Difference (I-J)
Computer Programming, I	**7.31**	**1.62**	**6.15**	**0.99**	**3.054**	**0.003**	**1.17****
System Programming	6.14	1.37	5.70	1.02	1.321	0.190	0.44
Data Structures	7.10	1.67	6.70	1.27	0.992	0.324	0.40
Operating Systems	5.89	1.18	5.60	0.94	1.010	0.315	0.29
Object Oriented Programming	7.19	1.61	7.03	1.85	0.386	0.700	0.16
Software Technology, I	8.04	1.21	8.00	1.50	0.134	0.894	0.04
Databases, I	6.03	1.01	6.35	1.39	-1.143	0.256	-0.32
Human Computer Interaction	**6.75**	**1.24**	**7.35**	**1.85**	**-1.869**	**0.045**	**-0.60***

Note. *The difference is significant at the 0.05 level

**The difference is significant at the 0.01 level

The statistical analysis reveals that the only difference statistically significant in favor of males is in the mean grade of *'Computer Programming I'* [Mean difference=1.17; t (87)=3.054, p=0.003]. On the other hand, females performed statistically significant better in '*Human Computer Interaction'* (Mean difference 0.60 in favor of females) [t(87)=-1.869; p=0.045]. It is worth noting that neither males nor females achieved excellent performance in these eight compulsory courses, as there was no single grade equal to 8.5 or higher.

6.2.2.2 SS electives: graduate preferences. Regarding graduate selections, it is worth noting that there are 14 electives for the SS division that were selected by a very small number of females (fewer than 5; 25% of female graduates). These courses were: *core programming courses ('C Lab', 'Java Lab', 'C++ Lab', 'Theories of Programming Languages'), databases ('Database Management Systems', 'Information retrieval', 'Databases II'), software applications ('Current Software Systems', 'Distributed Systems', 'Data and information visualization')* and other *advanced and special topics in SS ('Advanced topics in Programming', 'Advanced Topics in Databases', 'Special topics in software systems').* The above-mentioned courses were also selected by less than 25% of male graduates. Even though the above mentioned 14 electives reveal the subjects that females do not prefer, they are not taken into account in the performance analysis as they are selected by fewer than five graduates (see Table 17 and 18 in the Appendix II for a review of the statistical analysis for these courses).

For the remaining 13 elective courses, Table 15 illustrates the percentage of male and female graduates who selected the corresponding elective courses, and the mean and standard deviation values of the grades of male and female graduates for each course. The chi-square tests for independence indicate that there are significant associations in favor of males in the course *'Advanced User Interfaces, VR'* [X_2 (1) = 4.701, p = 0.030] and in favor of females in the course *'Machine learning & data mining'* [X_2 (1)=4.260, p = 0.039].

Table 15

Preferences and performance in 'Software Systems' electives

Graduates' preferences and performance in *'Software Systems'* electives									
	Group Statistics						Independent Samples Test T test for equality of means		
	Preferences		Performance						
	Male	Female	Male		Female				
Courses	graduates who selected the course (%)		Mean grade (J)	SD	Mean grade (J)	SD	t	Sig (2-tailed)	Mean difference (I-J)
Internet Services	**31.88**	**25**	**8.6**	**1.11**	**7**	**1.87**	**2.102**	**0.030**	**1.60***
Advanced topics in SS	**42.03**	**35**	**9.17**	**0.80**	**8.29**	**1.11**	**2.428**	**0.021**	**0.88***
Multimedia Technology	47.83	40	6.85	1.67	6.00	1.07	1.371	0.178	0.85
Data management systems	50.72	50	7.31	1.42	6.65	1.33	1.321	0.193	0.66
Logic and Functional Progr.	44.93	50	6.76	1.42	6.60	1.10	0.321	0.750	0.16
Compilers II	49.28	40	6.57	1.30	6.56	1.89	0.020	0.984	0.01
Advanced User Interfaces, VR	62.32	35	8.74	0.98	9	0.82	-0.654	0.516	-0.26
Artificial Intelligence	82.61	75	7.96	1.47	8.23	1.70	-0.628	0.532	-0.27
Information Systems	49.28	35	7.50	1.46	8.09	1.04	-1.241	0.221	-0.59
Intelligent Systems & Apps	42.03	30	7.50	1.65	8.42	0.92	-1.072	0.291	-0.81
Systems security	**17.39**	**30**	**8.41**	**1.32**	**7**	**1.56**	**2.345**	**0.023**	**1.41***
Machine learning & data mining	21.74	45	8.33	1.63	7.89	1.62	0.648	0.524	0.44
System analysis	52.17	55	7.51	1.48	8.09	1.04	-1.196	0.238	-0.58

Note. *The difference is significant at the 0.05 level

6.2.2.3 SS electives: graduate performance. Table 15 shows that the differences in the mean grades, in favor of males, that are statistically significant concern: (a) *'Internet Services'* [Mean difference=1.60; t(87)=2.102; p=0.030), (b) *'Advanced topics in Software Systems'* [Mean difference=0.88; t(34)=2.428; p=0.021], and (c) *'Systems Security'* [Mean difference=1.41; t(87)=2.345; p=0.023].

Interestingly, despite the fact that female graduates achieved higher mean grades in half of the electives of this division, the statistical analysis did not reveal any statistical significant differences in favor of females.

6.2.3 Graduate Preferences and Performance in '*Computer Technology and Computer Systems*' (CTCS) courses

6.2.3.1 CTCS compulsory courses: graduate performance. The performance, in terms of mean grades, of male and female graduates regarding CTCS compulsory courses are illustrated in Table 16.

Table 16

Performance in 'Computer Technology and Computer Systems' compulsory courses

Graduates' performance in *'Computer Technology and Computer Systems'* compulsory courses							
	Group Statistics				Independent Samples Test		
	Male		Female		T test for equality of means		
Courses	Mean grade (I)	SD	Mean grade (J)	SD	t	Sig. (2-tailed)	Mean Difference (I-J)
Computer Architecture, I	7.93	1.59	7.85	1.69	0.207	0.836	0.845
Logic Design	7.28	1.48	6.83	1.40	1.212	0.229	0.450
Computer Networks, I	7.16	1.31	7.18	1.35	-0.047	0.963	-0.156

It seems that male students performed better than females in 2 out of the 3 courses while girls had a marginally higher mean grade in "*Computer Architecture I*" compared to males. Nevertheless, these differences in the mean grades are not statistically significant.

6.2.3.2 CTCS electives: graduate preferences. Regarding graduate choices, a review of the number of male and female graduates who selected each course reveals that a small number of females (fewer than five female graduates) selected courses related to *advanced computer networks issues* (*'Advanced Computer Network Issues', 'Computer Communications and Networks II', 'Digital Signal Processing'*) and *computer engineering (*'*Synthesis of Digital Architectures*', '*Introduction to embedded systems*') and *'Robotics', 'Computer Architecture II'*; and *'Wireless & Mobile Communications'*. All the aforementioned courses were also selected by fewer than 14 males (20% of male graduates). The above mentioned nine courses were not taken into consideration in the performance analysis (see Table 19 and 20 in the Appendix II for a review of the statistical analysis for these courses).

Table 17 demonstrates the percentage of male and female graduates who selected the rest of electives (6 out of 15 electives) from the CTCS division, and the mean and standard deviation values of the grades of male and female graduates for each course. The chi-square tests for independence indicate that males, at a significantly higher percentage compared to that of females, prefer courses related to computer architecture, such as: (a) *'Hardware Description Languages II'* [X_2 (1) = 11.221, p = 0.001], and (b) *'Computer organization'* [X_2 (1) = 6.033, p = 0.014]. Regarding female graduate choices, Table 17 shows that a higher percentage of them compared to that for males selected certain courses, but chi-square tests indicate that there are no significant associations between gender and those course selections.

Table 17

Preferences and Performance in 'Computer Technology and Computer Systems' electives

Graduates' preferences and performance in *'Software Systems'* electives									
	Group Statistics						Independent Samples Test T test for equality of means		
	Preferences		Performance						
	Male	Female	Male		Female				
Courses	graduates who selected the course (%)		Mean grade (I)	SD	Mean grade (J)	SD	t	Sig (2-tailed)	Mean difference (I-J)
Hardware Description Languages, I	55.07	55	7.09	1.63	6.59	1.39	0.926	0.359	0.50
Computer Organization	91.30	70	8.10	1.43	8.25	1.42	-0.348	0.729	-0.15
Advanced Computer Architectures	23.19	35	7.13	1.02	7	0.82	0.284	0.779	0.13
Digital Circuit Design	30.43	35	8.45	1.40	8.57	1.10	-0.205	0.839	-0.12
Hardware Description Languages, II	52.17	30	8.85	1.18	9.17	0.75	-0.585	0.568	-0.32
Information Theory & Coding	**24.64**	**40**	**5.65**	**0.95**	**6.69**	**1.46**	**-2.148**	**0.042**	**-1.04***

Note. *The difference is significant at the 0.05 level

6.2.3.3 CTCS electives: graduate performance. As shown in Table 17, males performed better compared to females in two electives, but the mean differences in favor of males are not statistically significant. Conversely, the statistical analysis indicated that the difference in the mean values is statistically significant in the case of '*Information theory and coding'* in favor of females [Mean difference=1.04; t(34)=-2.148; p=0.042].

All in all, except the previously mentioned course, it seems that male and female graduates performed equally well in the electives of CTCS division.

6.2.4 Graduate Performance in '*Mathematics & Physics*' (M&P) courses

The analysis of the grades of the graduates in M&P courses (see Table 18) reveals that male graduates performed better than females in 5 out of the 6 Math courses whereas in *'Physics I'* female graduates had a higher mean grade. Nevertheless, the independent sample t-test indicated that the only statistically significant differences in favor of males in the mean grades were in one course; '*Linear Algebra'* [Mean difference=0.89; t(87)=2.782; p=0.007]. Yet, both male and female graduates achieved mean grades in all M&P courses far below 8.5 ('Excellent').

Table 18

Performance in 'Mathematics & Physics' compulsory courses

Graduates' performance in *'Mathematics & Physics'* compulsory courses							
	Group Statistics				Independent Samples Test		
	Male		Female		T test for equality of means		
Courses	Mean grade (I)	SD	Mean grade (J)	SD	t	Sig. (2-tailed)	Mean Difference (I-J)
Linear Algebra	**6.44**	**1.31**	**5.55**	**1.06**	**2.782**	**0.007**	**0.89***
Prob. Theory & Statistics	7.14	1.84	6.45	1.68	1.500	0.137	0.69
Mathematics I	6.59	1.43	5.98	1.27	1.728	0.088	0.61
Arithmetic Analysis	7.10	1.58	6.60	1.47	1.265	0.209	0.50
Mathematics II	6.33	1.58	6.13	1.61	0.518	0.606	0.21
Physics I	7.28	1.83	7.38	1.89	-0.213	0.832	-0.10
Discrete Mathematics	6.20	1.05	6.63	1.06	-1.581	0.117	-0.42

Note. *The difference is significant at the 0.05 level

6.2.5 Graduate Preferences and Performance in '*General Education*'(GE) electives

6.3.5.1 GE electives: graduate preferences. Electives in GE cover a wide range of subjects that can be applied to many different careers and students can choose them according to their interests. An inspection of the number of graduates who selected each of the electives in GE uncovers the fact that females did not prefer courses (courses selected by 1-2 females) related to *marketing and management perspective of CS* (*'Introduction to Economic Science I'*, *'Introduction to Economic Science II', 'New product and service development'*), the *study of mathematical models* (*'Game Theory'*), and specific issues related to social implications of CS *'Legal issues in informatics'*. The aforementioned five courses were also selected by fewer than 10 male-graduates (7%). Since these courses were selected by a few students, they were not considered in the performance analysis (for a review of the statistical analysis of these courses see Tables 21 and 22 in Appendix II).

Table 19 reveals that the majority of the remainder of GE electives were selected by a higher percentage of females than males. Nonetheless, the chi-square tests for independence indicate that females, at significantly higher percentages compared to those of males, preferred courses regarding *Humanities and Social Sciences,* such as: (a) *'Pedagogy'* [X_2 (1) = 3.771, p = 0.048], (b) *'Sociology'* [X_2 (1) = 3.662, p = 0.049], and (c) '*Cognitive Science'* [X_2 (1) = 14.175, p = 0.001].

6.2.5.2 GE electives: graduate performance. Male graduates performed better, compared to females, in half of the electives. However, the statistical analysis reveals that there was a statistically significant difference in the mean grades in favor of males in *'Social and Professional Issues'* [Mean difference=2.66; t(87)=4.310; p=0.001]. Likewise, the statistical analysis reveals that there was a statistically significant difference in the mean grades in favor of females in *'Differential Equation'* [Mean difference=1.36; t(87)=-1.987; p=0.047].

All in all, an inspection of the mean grades reveals that male and female performance in GE electives was remarkable. In fact, female graduates performed excellently (mean grade equal to or higher than 8.5) in more electives compared to males (11 and 7 GE electives correspondingly).

Table 19

Preferences and Performance in 'General Education' electives

Graduates' preferences and performance in *'General Education'* electives									
	Group Statistics						Independent Samples Test T test for equality of means		
	Preferences		Performance						
	Male	Female	Male		Female				
Courses	graduates who selected the course (%)		Mean grade (J)	SD	Mean grade (J)	SD	t	Sig (2-tailed)	Mean diffrence (I-J)
English	92.75	80	6.60	1.07	6.38	1.48	0.671	0.504	0.22
Social and Professional Issues	**18.84**	**25**	**8.46**	**1.20**	**5.8**	**1.10**	**4.310**	**0.001**	**2.66***
English Terminology	94.20	100	7.30	1.24	6.87	1.23	1.339	0.184	0.43
Computers and Education	27.54	30	8.05	1.18	8.50	1.22	-0.804	0.429	0.55
History of Computers	73.91	80	8.06	1.07	7.81	1.22	0.778	0.439	0.25
Pedagogics	68.12	90	7.13	1.74	7.14	1.53	0.022	0.983	0.01
Sociology	27.54	50	8.63	1.38	8.60	1.89	0.051	0.959	0.03
Didactics of Informatics	20.29	25	8.86	0.66	9	1.41	-0.218	0.837	-0.14
Cognitive Science	11.59	25	9	1.30	9.80	0.45	-1.301	0.220	-0.80
Psychology	34.76	55	7.79	1.44	8.63	1.14	-1.706	0.097	-0.84
Management Info Systems	13.04	35	8.40	1.14	9.25	0.96	-1.189	0.273	-0.85
Banking IT	11.59	25	7.63	1.89	8.60	0.82	-1.281	0.228	-0.97
Differential Equation	**42.03**	**45**	**7.31**	**1.91**	**8.67**	**1.78**	**-1.987**	**0.047**	**-1.36***

Note. *The difference is significant at the 0.05 level

6.3 Study2: Review of Main Research Findings

This section presents a review of the main findings of '*Study2'* of this thesis in terms of gender and CS student: (a) course preferences (sub-aim2.1) and (b) course performance (sub-aim2.2). These findings are discussed in the next section as a response to the research questions posed in the context of the abovementioned sub-aims.

6.3.1 Gender and Computer Science graduate preferences (RQ.2.1.i)

The analysis of the data shows that the statistically significant different selections in favor of males related to three courses; namely, two electives regarding computer architecture from the CTCS division *('Hardware Description Languages II'* and *'Computer organization'*) and one course from the SS division (*'Advanced User Interfaces, VR'*). Male graduates also selected more courses than did females from the SS and CTCS divisions, although not to a significant level. General Education electives were also not as popular among male students as among females. In that sense, the course selections of male graduates from the dept under study seem to follow some of the findings of earlier studies in other STEM fields which support that males take mathematics, engineering, Computing, and physical sciences in higher numbers when compared to females (Amelink, 2009; Coley, 2001).

On the other hand, more females than males –at a statistically significant level– expressed a preference for the following seven courses: (a) three courses from the TCS division (namely; '*Computational Geometry',* '*Cryptography'*, and '*Computer fractals'*), (b) one course from the SS division (*'Machine learning & data mining'*), and (c) three courses from the GE division related to *humanities and social sciences* (namely; '*pedagogy'*, '*sociology'* and '*cognitive science'*). The previously mentioned female graduates' selections are in accordance with the findings of relevant studies in CS, which support the view that females prefer the social aspects of CS and the solutions of community problems over Computing for the sake of Computing (Margolis et al., 2000). They seek to interact with people rather than things, desire to be helpful to others or society, and pursue a combination of career and family (Beyer, 2014) in a 'balanced' life with multiple roles and goals (Eccles, 2007). Such a tendency and female student preferences in social sciences and humanities have also been mentioned in earlier studies in other STEM fields (Amelink, 2009; Coley, 2001).

Nevertheless, some courses in the CS curriculum were not a popular choice with either female or male graduates (selected by less than 25% of both of them). These concerned: (a) *applied mathematics and theoretical CS, the study of mathematical structure and other advanced topics* (from the TCS division), (b) *core programming courses, databases, software applications, and other advanced and special topics in SS* *(*from the SS division), (c) almost one third of the electives from the CTCS division, which were about *computer engineering, robotics* and *advanced computer network issues, and* (d) the *marketing and management perspective of CS,* and *the study of mathematical models* (from the GE division).

Based on all the above, it would appear that males seem to prefer *hardware and software engineering courses*, while females prefer to study courses related to *theoretical issues* in CS as well as to *humanities and social sciences.* However, this study provide useful insight into males' and females' preferences in specific domains in CS education that, till now, was mainly explored from other studies in the scope of what teachers believe about boys' and girls' preferences (Berdousis & Kordaki, 2019; Kordaki & Berdousis, 2019; 2013).

6.3.2 Gender and Computer Science graduate performance (RQ.2.2.i)

The analysis of the data shows that, regarding graduate performance in the compulsory courses, the only differences in the mean grades that reach statistical significance, in favor of males, concerned one core programming course (*'Computer programming'*), and one Mathematical courses (*'Linear Algebra'*).

Considering the electives, the mean grades of male-graduates which were statistically significant – in favor of males – referred to just four courses; namely, three courses from the SS division (*'Information management on the Internet', 'Advanced topics in Software Systems'* and *'Systems Security'*) and one course from the GE division (*'Social and Professional Issues'*). Despite the fact that males performed better than females in more electives of the SS division and in GE courses that covered a variety of issues, their mean grades did not reach a significant level of difference. Finally, no statistically significant differences in favor of males emerged regarding the electives that they selected from the TCS and CTCS divisions.

In contrast, females performed better than males in some compulsory courses, but the only statistically significant difference in favor of females concerned '*Human Computer Interaction*'. Despite the lower mean grades in most of the compulsory courses, female graduates performed equally well, or even better, in electives. Specifically, females performed better than males in more TCS electives, and in some of the electives included in the SS division, yet these differences are not statistically significant. Moreover, even though females performed better than males in the majority of the CTCS electives, the only statistically significant difference in the mean grades in favor of females concerned just one course: '*Information theory and coding'*. Finally, regarding GE electives, females actually performed well, achieving excellent mean grades in 4 electives in the field of *Humanities* and *Social Sciences*. Nevertheless, the only statistically significant difference, in favor of females, in GE electives concerned '*Differential Equations*' (Berdousis & Kordaki, 2014a; 2014b).

Chapter 7

Computing Teachers' Gender-related Beliefs and Practices

Summary: This chapter presents in detail the context and the results of '*Study3: Computing Teachers' Gender-Related Beliefs and Practices'* of this thesis. A review of the main research findings is also presented as a response to the research questions posed according to the aims of this study.

7.1 Context of Study3

7.1.1 Aim of the Study

The aim of *Study3* was threefold. The first aim of *Study3* was to investigate CTs' personal gendered experiences and beliefs about themselves as teachers, boys and girls, CS as a high school subject as well as its teaching and learning, their practices in class and gender differences in CS.

The second aim of *Study3* was to design an empirical study to investigate the aforementioned CTs' real class practices to achieve a degree of insight into the way these teachers interact and communicate with boys and girls during the class. The third aim of *Study3*, consisted of an attempt to investigate possible associations between these CTs' beliefs and their actual teaching practices. To that end, some insight can be obtained into essential specific beliefs held by such teachers that would appear to exert influence on their class practices in relation to boys and girls. For each of these sub-aims one research question was posed: RQ3.1.i, RQ3.2.i, and RQ3.3.i (see chapter 4, section 4.2.3).

7.1.2 Methodological Choices

The methodological choices of *Study3* was based on the theoretical concept of *'The Research onion'* (see Chapter 4, section 4.4), which is demonstrated, in term of onion layers, in Figure 5. The aims of *Study3* were approached through a two phase research experiment. In the first phase CTs' practices were observed while in the second phase their beliefs were investigated. For the purpose of the research both quantitative (observations) and qualitative (interviews) data collection techniques and analysis procedures (*mixed methods)* were employed. Data collection and data analysis are discussed in detail next in this section.

7.1.2.1 Data Collection and Instrumentation. The sample of this study was 20 CTs coming from 16 secondary level schools in Greece. These schools were selected from urban and rural areas of the mainland of Greece, as well as from Greek islands, namely: Arcadia, Laconia and Dodecanese. The sample formation was realized following the ‘convenient’ sample procedure (Saunders et al., 2009) because of the convenient accessibility and the proximity of the researcher.

To conduct the research, official approval was requested by the Hellenic Ministry of Education, Research and Religious Affairs through the Institute of Educational Policy (IEP). After granting this approval (for 35 schools; see appendix III.1), initial contact with the Principals of these schools was made -by the researcher- to investigate their consensus to participate in the research experiment (see appendix III.2). Just half of the school Principals (18) replied positively. Next, the CTs of those 18 secondary schools were contacted and their willingness to participate in the experiment was inspected (see appendix III.3). Finally, 20 CTs from 16 schools corresponded and their class timetables, class sizes, and computer labs for CS courses were ascertained.

Twelve of these CTs were males (henceforth labeled CT1, CT2, CT3, … , CT12) and the rest eight were females (henceforth labeled CT13, CT14, CT15, … ,CT20). These teachers taught in typical public high schools (junior, general and vocational), located in three regions in Greece (Arcadia, Laconia, Dodecanese) covering the two stages of the secondary education in Greece.

Table 20 presents basic information about these CTs. The mean age of the male CTs was 39.08 years (SD=6.52) and their mean teaching experience was 12.25 years (SD=4.692), while the mean age of the females was 43.38 years (SD=5.58) and their mean teaching experience was 15.75 years (SD=5.725). Regarding their education, CTs held the following different undergraduate degrees, males: Computer Science (10 teachers), Mathematics (2 teachers); females: Computer Science (7 teachers), Physics (1 teacher). Considering graduate studies, half of the male CTs held a master’s degree, all of them in CS, while two of female CTs had a master’s degree in educational sciences (ES) and one in Economics. Both male and female CTs have attended seminars in CS and ES. In terms of teaching experience and educational background, this is a typical sample of Greek CTs.

Table 20

Description of the sample

Classification Assignments			Number (Percentage %) of CTs		
			Male	Female	Total
Age		30-40	**9 (75)**	2 (25)	**11 (55)**
		41-50	2 (17)	**5 (63)**	7 (35)
		51+	1 (8)	1 (13)	2 (10)
Education	Undergraduate degree	Computer Science	**10 (83)**	**7 (88)**	**17 (85)**
		Mathematics	2 (17)	-	2 (10)
		Physics	-	1 (13)	1 (5)
	Master's degree	Computer Science	**6 (50)**	-	6 (30)
		Educational Sciences	-	2 (25)	2 (10)
		Other	-	2 (25)	2 (10)
		Not	**6 (50)**	**5 (63)**	**11 (55)**
	Seminars	Computer Science	**10 (83)**	5 (63)	**15 (75)**
		Educational Sciences	7 (58)	**7 (88)**	14 (70)
		Other	-	1 (13)	1 (5)
Teaching Experience (years)		7-10	4 (33)	1 (13)	5 (25)
		11-15	**7 (58)**	**4 (50)**	**11 (55)**
		15+	1 (8)	3 (38)	4 (20)
Current Teaching Position		Junior High School (Gymnasium)	4 (33)	**5 (63)**	**9 (45)**
		General High School (GL)	**5 (42)**	2 (25)	7 (35)
		Vocational High School (VL)	3 (25)	1 (13)	4 (20)

One didactic hour (45 minutes) was selected as appropriate for the observation of for each of CTs practices, mostly because of the timetable and the presence of equal, or almost equal, number of girls and boys in class. The parents of the students in the selected classes were informed about the research experiment and their consent was also confirmed (see appendix III.4). After all the above, the interviews and the class observations were scheduled and realized from March 2017 to April 2017. After the class observations, structured interviews were conducted with each one of the CTs to elicit their beliefs.

Interviews. For the first purpose of *Study3* structured interviews were conducted to investigate the CTs' personal experiences as well as their conceptions and beliefs about the following issues: (a) themselves as Computing teachers, (b) CS as a discipline and its teaching and learning, (c) boys and girls in relation to CS, (d) gender issues in a Computing class, and (e) gender differences in CS. During these interviews, CTs were asked to provide answers to a number of open questions (Qi, i = 1,.,20) banded into five groups (see Appendix III.8).

Specifically, the first group of questions (Q1, Q2, Q3, and Q4) was aimed at probing teachers' personal experiences of different treatment in school because of their gender (Q1), their motives in becoming Computing teachers (Q2), their self-expectations as CTs (Q3), and their strengths and weaknesses as teachers (Q4). The second group (Q5, Q6, Q7, Q8) was targeted at exploring teachers' beliefs regarding the special features of CS as a school subject (Q5), the role of the Computing Teacher (Q6) and the appropriate teaching practices (Q7), as well as the competences needed for a student to fulfill the requirements of the CS subject (Q8). The third group (Q9, Q10, Q11, Q12, Q13, Q14, and Q15) was designed to elicit teachers' beliefs about boys' and girls' interests (Q9), preferences (Q10) and potential in CS (Q11), as well as to reveal any (differentiated) gendered beliefs concerning males' and females' way of learning (Q12), special characteristics regarding CS courses (Q13), and reasons for possible incompetence (Q14). Eventually, CTs were asked to describe boys and girls regarding CS using specific adjectives (Q15). The fourth group elicited teachers' beliefs regarding the kind of their interactions with boys and girls (Q16) and their expectations from them (Q17). CTs were also asked to describe situations in class that reinforce gender differences in the Computing class (Q18). Finally, the fifth group of questions addressed to the CTs served as a reflection on their teaching practices in terms of student gender so far, as well as on their attitudes towards the gender gap in CS. In fact, CTs were asked to state if they believe that gender differences in CS exist (Q19) and if the gender gap in CS is a problem (Q20), as well as to recall any situations where they encouraged or discouraged the gender gap in CS (Q21) and if they considered gender issues in their teaching practices until our session (Q22). All the questions included in the aforementioned groups are reported in the Results' section, along with the answers given by the teachers.

Observations. For the second purpose of *Study3*, class observations were conducted in an attempt to examine various instructional behaviors of CTs toward girls and boys in computer class from a gender-sensitive viewpoint. More specifically, CTs' practices were inspected in terms of CT-student interactions, which were examined in the context of four major axes: (a) frequency and percentage of interactions between CT and girls/boys, (b) type of interactions and level of questioning being asked to girls/boys, (c) type of verbal feedback given by CTs to girls/boys, and (d) non-verbal behavior of CTs during interactions, and especially the wait time and the physical closeness of CT – student.

Each of the four axes is discussed below in an attempt to make clear the necessity of its investigation.

(a) Frequency and percentage of interactions between CT and girls/boys. During class, a CT can interact with a girl, a boy, a group of students or the whole class. Those interactions could be initiated by the CT, a girl or a boy. Focusing on the interactions initiated by the CT, a gender–sensitive CT calls on girls and boys equally or address questions to the whole class, while a gender–biased CT initiates more interactions with girls or boys (Trbocv & Hofman, 2015). Taking into account the interactions initiated by the girls and boys, overall, a CT may interact equally with boys and girls, more with boys compared to girls, or more with girls compared to boys. In an attempt to quantify the interactions, the number of interactions between CT and girls/boys (frequency) and the percentages has to be estimated in order to determine whether a CT can be characterized as gender–sensitive or gender–biased.

(b) Type of interactions and level of questioning being asked to girls/boys. CT – student verbal interactions in class can be of two types: *conduct* or *intellectual question*. **'***Conduct'* interactions concerns the behaviour and deportment of student, while *'intellectual questions'* concern cognitive and academically related topics, intellectually engaging, requiring from students to perform activities that require effort, activating (lower or higher order) thinking skills (Tracy & Lane, 1999). Those '*intellectual*' questions are further classified as *low* and *high* level questions. In fact, regarding intellectual questions, Bloom (1956) has categorized the levels of reasoning skills required in class situations, revealing different levels, each requiring a higher level of abstraction from the students. In that sense, the types of intellectual questions asked by the CTs to their students could be of several types (Bloom, 1956). '*Knowledge Level Questions'* are those questions that require students to recall facts, provide a common ground to prepare for higher level questions, or brainstorm. *'Analysis Level Questions'* regards questions that require from the students to relate ideas, compare pros and cons, explore assumptions, and promote logical thinking, while '*Evaluation Level Questions'* are those questions that require students to move beyond the facts and analysis to develop their own judgments. '*Knowledge level questions*' can be classified as low level questions while 'Analysis *Level Questions'* and 'Evaluation *Level Questions'* as high level questions. It is obvious that teachers, who attempt to move students up the taxonomy as they progress in their knowledge, seek to create thinkers as opposed to students who simply recall information. The use of higher-level questioning techniques facilitates a wide range of thinking skills. Boys are challenged in this way more often than girls (Sadker & Sadker, 1994). In that sense, teachers who address high level questions to students empower them to reach higher levels of reasoning skills.

(c) Type of verbal feedback given by CTs to girls/boys. The feedback teachers give to students' work and their answers in class affects their learning, as well as their self-esteem and participation in class (Hattie & Timperley, 2007). Some kinds of teacher feedback (positive) help students to learn and think, while others (negative) cause students to be fearful and disengaged. Feedback that enables students, making them think and learn from their mistakes, and feedback praising the substance of their work, helps them progress in their learning process and enhance their self-esteem (Hattie & Timperley, 2007; Sadker et al., 1984). On the other hand, teachers who just accept a student answer without further comments or praise, give no response or provide negative feedback that is personal or judgmental are not supportive for their students, deteriorating their self-esteem and giving them a lesser education (Hattie & Timperley, 2007). The INTERSECT observation system of Sadker et al. (1984) proposed two main different kinds of teacher feedback; *positive* and *negative*. The positive feedback was further analyzed to *'acceptance'*, *'praise'*, and *'enabling'*, while negative feedback was described as '*judgmental or criticism'*. *Acceptance* refers to situations where teacher comments imply that student performance is correct or appropriate but they are not so clearly and strongly stated. This is a more benign way to respond to student actions by merely acknowledging students efforts using verbal phrases of acceptance. Research data shows that girls receive acceptance comments more frequently than some words of praise (Sadker & Sadker, 1994). *Praise* concerns explicit comments which positively reinforce student performance, and involves both the content of the teacher's comment and the intonation of the teacher's voice. Teacher's praise encourages continued participation and investment in learning. Teachers use praise more readily with boys than with girls (Sadker & Sadker, 1994). *Enabling* represent a constructive teacher comment, usually encouraging, moving the learning process along and challenging the student to think. *Criticism* refers to explicitly negative teacher evaluation that implies clear, strong disapproval and it may involve a warning or penalty. Criticism provides students with feedback on their academic work and also their social behavior. Sadker and Sadker (1994) have shown that boys receive more criticism than girls. In some cases the teacher may give *no feedback* to the student without any clue about the correctness of their response. Some research evidence documents a disparity in the kind of feedback teachers give to boys compared to girls encouraging or discouraging girls' participation, affecting their self-esteem, and ultimately influencing their learning process (Hattie & Timperley, 2007). After all, CTs' feedback to girls and boys worth investigation as it may be a crucial factor for engaging or not girls in CS, boosting or weakening their self-esteem.

(d) Non-verbal behavior of CTs during interactions. The nonverbal behaviour of a CT reflects her/his ancillary behaviour and it can be elicited by examining: (i) wait time and (ii) physical closeness.

i. *Wait time*. "*Wait time is the period of silence between the time a question is asked and the time when one or more students respond to that question*"[17]. In fact, when a teacher poses a question to a student, or the whole class, waits some time before she/he terminates the response opportunity, usually by asking another student the same question, or by assisting / providing additional information. It is necessary to give students some time to think about the questions and provide an answer. Wait time results in more thoughtful responses and encourages participation by more students. Rowe (1972) found that the average length of wait time was 0.9

[17] https://www.teachervision.com/your-secret-weapon-wait-time

seconds while, in other cases, teachers on average only waited 0.7 to 1.4 seconds after asking another question (Stahl, 1994). Mansfield (1996) uncovered different wait times for boys and girls supporting that the average wait time for boys is 0.8 seconds and for girls 1.2 seconds. This short wait time reinforces impulsive and shallow thinking, effectively silencing those who need more time to think. Girls tend to want more time to consider answers to questions posed by teachers (Belenky, Clinchy, Goldberger, & Tarule, 1986). It is supported that wait time should be depending on the complexity of the question, the ability of the students and the clarity with which the question was asked (Mlama et al. 2005). In general, lower-level questions will take most students 1 to 5 seconds to answer, while higher-order questions that require more thought than the simple recall questions, could take anywhere from 6 to 10 seconds to provide a reply (Stahl, 1994; Mlama et al. 2005).

ii. *Physical Closeness.* Teachers sometimes organize classrooms to determine where students will be seated, and some students may be unconsciously kept at a distance, while, other times students have the chance to choose where they sit. Physical closeness means that the student and the teacher engage in interactions physically near one another. Several observation studies have examined room arrangement and teacher closeness to students and their impact on achievement, especially in science and math, and on class management (Sadker & Sadker, 1994). Proximity is not just a tool for class management; every student deserves the benefit of their teacher's presence. It is supported that the teacher has to make the appropriate arrangement and movements in the room to be near to each student for a portion of the class period. Students who do not experience the proximity of the teacher have fewer opportunities to feel important. Thus, the teacher has to find an effective way to ensure that all students benefit from the physical proximity to the teacher (Grayson, 2001)

Description of the Computing Teacher - Student Interactions Tool (CTSIT). In order to record and examine CT-student interactions in the scope of the four abovementioned analysis axes, a '*Computing Teacher-Student Interactions Tool*' (CTSIT) was built up adopting and reforming basic aspects of the interaction tools developed so far adjusting them to the purpose and the context of the current study (see appendix III.5).

In line with the analysis framework, the CTSIT was structured in four section assisting to determine: (a) the number and percentage of the interactions initiated by the CT to girls/boys and by students to the CT, (b) the type of interaction and the level of questioning being asked, (c) the type of verbal feedback received by girls/boys from their CT, and (d) the CTs' non-verbal behavior towards girls/boys in terms of wait time and physical position in the lab/classroom.

Keeping in mind the purpose of the CTSIT, the following information were recorded:

*(a) Initiator and receiver of the interactions***.** It was recorded who initiated the interaction, whether it was the CT, a girl or a boy. In case the initiator was the teacher, the 'receiver' was also noted (girl, boy, or class).

(b) The type of interaction as well as the level of questioning being asked. For each one of the interactions recorded, the type (conduct or intellectual question) as well as the level of questioning (low or high) were also noted. '*Knowledge'* level questions were classified as low level questions while '*Analysis'* and '*Evaluation'* level questions were categorized as high level questions.

*(c) The type of verbal feedback given by the CT***.** It was recorded whether the CT feedback was *positive* (acceptance, praise, or enabling), *negative* (judgmental), or *neutral* (no feedback). *Acceptance* was recorded each time the CT explicitly or implicitly accepted a student answer as appropriate or correct making comments such as "ok", "uh huh", "right", and "yes". These reactions implied approval. Acceptance also was marked when a student offered a response and the CT did not make an explicit answer but instead continued with further comments or questions that implied the response was appropriate. *Praise* was recorded each time the CT made a comment clearly intended as praise or positive reinforcement, such as "Good job!", "That's exactly right", "Well done". *Enabling* was recorded each time the CT moved the learning process along and challenged the student to think requiring from her/him more complex mental processes than simple recall. *Criticism* was recorded each time the teacher's comments clearly and strongly

disapproved student's behavior or student's work. *No feedback* was recorded when the CT explicitly or implicitly gave no feedback to the student.

(d) The non-verbal behaviour of the teacher during the interactions. The non-verbal behaviour of the teacher was recorded in terms of: (i) wait time and (ii) physical closeness

i. *Wait Time:* It was recorded each time the CT allowed at least 5 seconds to students to think and answer a low level intellectual question and at least 10 seconds to reply to high-order questions, before she/he terminates the response opportunity, usually by asking another student the same question, assisting or providing additional information.

ii. *Physical Closeness*: It was recorded whether each CT was close or away from the student interacting with. The CT was close to the student when she/he moved towards the student or stood/sat next to her/him in a stationary position (a '▶' symbol was marked each time the teacher moved towards the student and a '🡻' symbol each time the teacher stood or sat next to the students in a stationary position). The teacher was away from the student when she/he posed a question from the board/chair or was in another place in the classroom (a '^' symbol was noted each time the teacher posed the question from the board/chair, and a '↺' symbol each time the teacher was in another place in the classroom).

7.1.2.2 Data Analysis. The data from the observations were analyzed quantitatively while the interview data were analyzed qualitatively.

Observations. For each one of the CT observed in the class the researcher completed the CTSIT (See Appendix III.5). After the end of the observations, the 20 completed manuscripts were collected and transcribed into an electronic format (see Appendix III.6). Next, for each one of the CTs, a table presenting quantitatively the information recorded was built. Due to the fact that, in many classes, there was an uneven number of boys and girls, the frequencies and the percentages in the aggregate tables were calculated after a deduction to equal number of boys and girls (see Appendix III.7). The data emerged from the observations of CTs' practices were firstly organized using the points included in the observation sheets. For each one of the analysis axes –

frequency of interactions, type of interaction and level of questioning, type of feedback, and CT non-verbal behavior – total tables with the data from the 20 CTs were formed. Next, for each one of the analysis axes CTs showing similar gendered behavior were grouped, resulting in the formation of specific profiles of teacher practices. These profiles were also examined for common points and differences, and as a result specific profiles of teacher practices were formed. Finally, possible associations between each individual teacher practices falling into each of the aforementioned categories, and the beliefs expressed during the interviews, were explored.

Here, it is worth mentioning that, for the purpose of this study, differences in CT-student interactions were only investigated under the four major axes of analysis and were exploited in order to outline CTs' profiles by grouping CTs practices whilst preserving anonymity. The content, the skills level of teachers and students, the teaching methods, and the lesson preparations were not reported or evaluated within this study. The CTs were not required to prepare special lessons or make special adjustments to their program, or that of the school, eliminating the necessity for changes to the usual running of the class being observed that would possibly inhibit the effectiveness of this research study.

Interviews. The interviews with CTs were conducted in Greek. All of them were recorded and then transcribed. To analyze the interview transcripts, the method of thematic analysis was used. This method is used for the identification of emerging themes and patterns in a data set which should underline important constellation of meanings (Braun and Clarke, 2006). A pattern of meaning that is found in a data set constitutes a theme. Thematic analysis is also associated with coding which refers to the creation of categories related to data that contribute to a theme (Gibson, 2006; Saldana, 2009).

In this study, NVivo software was used to code the data into theme categories. In fact, the data were firstly organized according to the questions asked. For each question, the data were analyzed by closely reading the transcripts several times. During the first reading, a high-level overview of the data was achieved. In the second round, specific words and phrases that captured a specific theme deriving from each question were highlighted. As an outcome, specific theme categories of CTs' beliefs were created.

These categories were examined closely in relation to each other to identify what they had in common and how they differed.

Depending on the issue asked, the categories of teachers' beliefs were classified as: *'empowering'* and *'constraining'* beliefs, *'gender-neutral'* and *'gendered'* beliefs, *'gender-sensitive'* and *'gender-biased'* beliefs. Specifically, CTs' views about themselves as teachers and CS as a school subject as well as its teaching and learning were classified as *'empowering'* beliefs and *'constraining'* beliefs (Kordaki, 2013); the first can help teachers improve the quality of their teaching through practices based on modern learning theories, while the second beliefs supposes the opposite. CT's views and class practices regarding student gender were classified as *'gender-neutral'* beliefs and *'gendered'* beliefs; the former suggest that CTs avoid distinguishing roles according to student gender, while the latter imply that CTs hold different beliefs about boys and girls favoring in some cases students of one gender over the other. Finally, CTs' beliefs about general gender differences in CS and their role in encouraging/discouraging gender gap were classified as *'gender-sensitive'* beliefs and *'gender-insensitive'* beliefs; the first suppose that CTs are aware of gender issue and disparity in CS recognizing their important role in perpetuating or mitigating the differences, while the second suppose the opposite. It is worth noting here that the participants did not characterize their beliefs as *'empowering'* or *'constraining'*, *'gender-neutral'* or *'gendered'* beliefs, *'gender-sensitive'* or *'gender- insensitive'*.

7.2 Study3: Results

In this section, the data coming from CTs' expressed beliefs are firstly presented while next, the data emerged from their class practices are reported.

7.2.1 Computing Teachers' Beliefs

The results of the analysis of the teachers' answers during the interviews are presented according to the grouping of questions (issues). For each one of the issues discussed, Tables 24 to 28 present the question at hand (column 1), the categories derived from the CTs answers (column 2) as well as the number and the percentage of CTs who fall into each category in terms of CTs' gender (columns 3 and 4) and overall (column 5). The bold numbers in the Tables indicate the categories that most CTs fit in. It is worth noting that CTs expressed beliefs that in some cases fall into more than one category. In text, the numbers in parentheses present the number of CTs that expressed each opinion at hand.

7.2.1.1 CTs' personal experience, motivation and self-expectations. During the interviews CTs were asked several questions about: (a) their personal experiences (Q1: Were you treated in a different way because of your gender in school?), (b) their motivations (Q2: What were your motives in becoming a Computing teacher at High School?), (c) their self-expectations (Q3: Can you address any self-expectations as a Computing teacher?) and (d) their strengths and weaknesses (Q4: What are your strengths/weaknesses as a Computing teacher?). Table 21 presents the data emerging from CTs answers to the aforementioned questions.

CTs previous gendered experience as students. As it is shown in Table 24, half of the CTs (10) claimed that they cannot recall any differential treatment, because of their gender in school, while the rest stated that their teachers treated boys and girls in different ways: (a) gentler towards females (4), (b) indifferent or strict to boys (7). Some of them tried to explain further, making speculations about that different treatment: good/bad behaviour of the females/males correspondingly (2), different expectations from boys and girls (1), good/bad performance for females/males correspondingly (4), and the belief that girls are weak in STEM courses (1). Thus, it seems that half of CTs had gender neutral previous experience in their schools while the rest half of them recalled gendered school experiences. Interestingly, a higher percentage of females (75%), compared to males (33%), stated that their teachers treated boys and girls in a different way.

Motivation. The motives of the CTs to become teachers were divided into 2 broader categories: *intrinsic* and *extrinsic*. For half of the CTs (10) their career choice was inspired by intrinsic motives, and specifically their love to teach and to interact with students. However, a considerable number of CTs (14) reported that they selected this profession driven by extrinsic motives, and specifically the advantages of the teaching job, such as: fixed salary and duties (9), balanced / relaxed life (4), and vocational rehabilitation (9) stating that this occupation was not their primary dream. The dominant motive for male CTs was the benefits of the teaching job, while for females their love to teach and interact with students. None of the female CTs identified their love for CS as a motive for selecting this occupation. Intrinsic motives can be characterized as ‘empowering’ motives for CT to become better in their job while extrinsic motives can sometimes constrain them.

Table 21

Personal Experience, motivation and self-expectations

Issue/Question	Interviews: Categories of CTs’ answers		Number (Percentage %) of CTs		
			Male	Female	Total
Different treatment because of gender/Q1	Yes		4 (33)	**6 (75)**	**10 (50)**
	No		**8 (67)**	2 (25)	**10 (50)**
Motivation/Q2	Intrinsic	Love to teach	4 (33)	**5 (63)**	9 (45)
		Love CS	2 (17)	-	2 (10)
	Extrinsic: Advantages of teaching job		**10 (83)**	4 (50)	**14 (70)**
Self-expectations/Q3	No expectations		7 (58)	3 (38)	**10 (50)**
	Become better CT		5 (42)	5 (63)	**10 (50)**
Strengths and Weaknesses/Q4	Strength	Teaching	5 (42)	**8 (100)**	**13 (65)**
		CS	**8 (67)**	1 (13)	10 (50)
	Weakness	Teaching	**5 (42)**	-	5 (25)
		CS	3 (25)	**6 (75)**	**9 (45)**
		None	4 (33)	2 (25)	6 (30)

Self-expectation. Half of the CTs want to become more efficient teachers (10), while the rest seem to have no self-expectations (10), stating that they just want to continue to be teachers without highlighting special goals. Just one male CT said that he plans to quit the teaching job and return to Computing industry. For females, it seems that their major concern is to become better and efficient teachers. Self-expectations could empower CTs to perform better in their job while non expectations could act as constrains in their professional development.

Strengths and Weaknesses. Most of the CTs (13) believe that their strong point is their teaching ability. Interestingly, all the female CTs (8) feel confident with their teaching ability and highlight it as their strong point, while some of them stated that they feel inadequate in keeping pace with the developments in CS (6). The majority of males (8) highlighted their competence in CS as their strong point and some of them recognize as a weakness their poor teaching ability (5), stating that they cannot provoke interest or deal with students. Six of the CTs (4 males and 2 females) feel confident and claim that they have no weak points, while some blame external factors (7), such as poor curriculum and institutional barriers that deter them from doing their job properly. It seems that male and female CTs are empowered/constrained by different capabilities. Female CTs are empowered by their good teaching skills and constrained by their weakness in CS knowledge while for males the opposite is true.

7.2.1.2 CTs' beliefs about CS as a school subject and its teaching and learning. Teachers' answers regarding their beliefs about the special features of CS as a school subject (Q5: What are the special features of CS subject in secondary education?), the role of the Computing Teacher (Q6: What should be the role of a CT in class?), the appropriate teaching strategies (Q7: What should be the implemented teaching strategies?), and the students' necessary competences (Q8: What skills are necessary for a student to fulfil the requirements of CS subject?) are reported in this section. Table 22 presents the theme categories derived from CTs' answers to the abovementioned questions.

Special features of CS as a school subject. As it is shown in Table 22**,** a considerable number of CTs (17) focused on the practical aspect of the CS as a school subject. Half of the male CTs (6) stated that CS is just a practical subject, while most of the females (6) pointed out the theoretical along with the practical side of the course. Half of the male CTs (6) emphasised on the cognitive aspect of CS mentioning that the CS subject can act as a mental tool enhancing students' abilities and skills, while others (4) stated that, within school, CS is just 'computer use'. Finally, just a few of the male CTs (3) mentioned that the basic feature of CS is programming. The belief that CS subject has both theoretical foundations and practical dimension and can act as a mental tool and trigger students' thinking can empower CTs improve the quality of their teaching.

Contrarily, the belief that CS as a subject has just practical applications and is just programming or computer use are narrow-minded beliefs that may constrain CTs' teaching practices.

Table 22

Computing Teachers' beliefs about CS as a school subject and its teaching and learning

Issue/Question	Interviews: Categories of CTs' answers	Number (Percentage %) of CTs		
		Male	Female	Total
Special features of CS as a school subject/Q5	A mental tool	**6 (50)**	1 (13)	7 (35)
	A practical subject	**6 (50)**	1 (13)	7 (35)
	A theoretical & practical subject	4 (33)	**7 (88)**	**11 (55)**
	Programming	3 (25)	-	3 (15)
	Computer use	4 (33)	2 (25)	7 (35)
Role of a CT/Q6	Traditional role	2 (17)	2 (25)	4 (10)
	CT as a facilitator	**11 (92)**	6 (75)	**17 (85)**
	No idea	1 (8)	1 (13)	2 (10)
Teaching strategies/Q7	Direct Teaching	5 (42)	**4 (50)**	9 (45)
	Project work in groups	**8 (67)**	**4 (50)**	**12 (60)**
	Real life activities	5 (42)	3 (38)	8 (40)
	Use of educ. software	3 (25)	2 (25)	5 (25)
	No idea	1 (8)	1 (13)	2 (10)
Student necessary competences in CS/Q8	Computer experience & Interest	8 (67)	4 (50)	12 (60)
	High cognitive skills	**10 (83)**	5 (63)	**15 (75)**
	Study, diligent students	2 (17)	**6 (75)**	8 (40)

Role of the Computing Teacher. Apart from one male and one female CT who had no idea, teachers' responses -regarding the appropriate role of the Computing teacher in class- fall into two categories: *traditional role* and *teacher as facilitator*. Interestingly, all, but one female, CTs claimed that in elective CS courses -where there are no time, curriculum and exam barriers- the role of a CT is to act as facilitator (make their students think, act, cooperate, and discover). In the compulsory courses some of the CTs (2 males and 1 female) admitted that the CT must accept the traditional role relying on the textbook, strictly follow the curriculum and adopt an exam-oriented teaching approach. However, both male and female CTs expressed that teachers, wherever possible, should act in a way that facilitates students to develop high cognitive skills. This belief can be characterized as empowering as it can help CTs improve the quality of their teaching through practices based on modern learning theories, in contrast to the belief of a traditional role for the CT which may constrain their teaching strategies and practices.

Teaching strategies. Apart from two CTs, male and female CTs mentioned several teaching strategies that should be implemented so as a CT achieve her/his goals. Most of them stated more than one teaching strategy suggesting that the teacher needs to adjust to the needs of her/his students, the curriculum, the course, the barriers, etc. It is worth noting that most of the male teachers (8) mentioned project work in groups engaging real life activities (5). For half of the female teachers (4) project work in groups is an appropriate strategy as well. Both male (5) and females (4) CTs suggested direct teaching when needed as well as the utilization of technology, proposing mainly drill and practice educational software (5). Teaching strategies based on modern learning theories, like group work, project work, and real-life activities, can empower the quality of CTs' teaching helping students develop high cognitive skills and abilities, whereas direct teaching and exploitation of drill and practice education software can be characterized as constraining hindering the development of those skills.

Student's necessary competences in CS. The majority of the male (10) and female (5) CTs highlighted high cognitive skills, such as mathematical/logical thinking, critical thinking and problem solving, as the essential capabilities for a student to meet the requirements of a CS course. Students' interest and personal engagement with different aspects of CS beyond school time seems to be a crucial factor for success in CS courses according to most of the male (8) and female (5) CTs. Finally, a few of the male (2) and most of the female CTs (6) argued that students have to be diligent and study at home. The belief that students need to have high cognitive skills can empower CTs plan and implement teaching strategies that would help students employ and develop those skills. On the other hand, the beliefs that only student interest in CS and personal engagement beyond school time or the diligence are the necessary and sufficient capabilities for a student to succeed, may constrain CTs' practices preventing them from realizing those teaching strategies that would help students develop those cognitive skills and abilities that are essential for learning.

7.2.1.3 CTs' beliefs about girls/boys and CS. This section presents the CTs' answers regarding their beliefs about boys' and girls' interests (Q9: What are males' and females' interests in your Computing class?), preferences (Q10: Do you believe that there are specific domains within the CS field that boys and girls prefer?) and potential in CS (Q11: How would you describe males' and females' potential in CS?), as well as their views about males' and females' way of learning (Q12: Do you believe that boys and girls learn CS in a different way?), their special CS characteristics (Q13: Could you describe males' and females' special characteristics in relation to CS subject?) and attributions of possible incompetence in CS courses (Q14: A male and a girl does not perform well in CS. Where would you attribute this fact?). Their overall descriptions of boys and girls (Q15: What adjectives would you use to describe boys and girls in a Computing class?) are also reported in this section. Table 23 introduces the categories emerged from the CTs answers to these questions.

Students' interests. When the CTs were asked about their students' interests regarding CS, all of them – apart from 3; who had no idea – stated that both boys and girls use different aspects of technology outside school in their free time. Even though some of them (4) expressed a *gender-neutral belief* just stating that both boys and girls use technology, a considerable number expressed *gendered beliefs* mentioning that boys and girls use technology, but in different ways. The majority of the CTs (11) pointed out that boys, mainly, spend their free time playing computer games, while females benefit the social aspect of technology, mostly communication and use of social networks (14). In some cases, these gendered beliefs are mainly *in favor of boys*, as some of the CTs (4 males and 2 females) claimed that boys do not just use technology, but also attempt to actively get involved with CS through hands on activities (like robotics) or software modifications.

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Table 23

Computing Teachers' beliefs about boys and girls

Issue/Question	Boys: Interviews: Categories of CTs' answers	Boys: Number (Percentage %) of CTs: Male	Female	Total	Girls: Interviews: Categories of CTs' answers	Girls: Number (Percentage %) of CTs: Male	Female	Total
Students' interest/Q9	Computer games	**8 (67)**	**3 (38)**	**11 (55)**	Social aspect of technology	**9 (75)**	**5 (63)**	**14 (70)**
	CS	4 (33)	2 (25)	6 (30)				
	No differentiation			4 (20)				
	No idea			3 (15)				
Students' preferences in specific domains of CS/Q10	All domains	**4 (33)**	-	**5 (25)**				
	Software	1 (8)	1 (13)	2 (10)	Use of technology	**4 (33)**	**1 (13)**	**6 (30)**
	Hardware	2 (17)	**3 (38)**	5 (25)				
	No differentiation			10 (50)				
Students' potential in CS/Q11	More likely to study and pursue CS	**10 (83)**	**4 (50)**	**14 (70)**	-			
	Both			6 (30)				
Students' way of learning/Q12	Challenging activities	3 (25)	**3 (38)**	**6 (30)**	Do not learn actually	**4 (33)**	-	4 (20)
	Personal involvement (beyond school)	**4 (33)**	1 (13)	5 (25)	Need effort / support	3 (25)	**7 (88)**	**10 (50)**
					Through school	3 (25)	1 (13)	4 (20)
	No differentiation			5 (25)				
Students' special characteristics regarding CS/Q13	High cognitive skills	3 (25)	1 (13)	4 (20)	Diligent students	**8 (67)**	**2 (25)**	**10 (50)**
	Confidence, interest, persistence	**7 (58)**	**4 (50)**	**11 (55)**	Need guidance, insecure	5 (42)	**2 (25)**	7 (35)
					Persistence	0 (-)	**2 (25)**	2 (10)
	No differentiation			6 (30)				
Attribution of students' incompetence/Q14	General incompetent in school	**8 (67)**	**6 (75)**	**14 (70)**	General incompetent in school	1 (8)	**3 (38)**	3 (15)
	Not interested in CS	5 (42)	-	5 (25)	Not interested in CS	**10 (83)**	**3 (38)**	**14 (70)**
	Lack of the needed abilities	1 (8)	1 (13)	2 (10)	Lack of the needed abilities	2 (17)	2 (25)	4 (20)
	Other issues	2 (17)	3 (38)	5 (25)	Other issues	2 (17)	1 (13)	3 (15)

Table 45 (continued)

Issue/Question	Boys: Interviews: Categories of CTs' answers	Number (Percentage %) of CTs: Male	Female	Total	Girls: Interviews: Categories of CTs' answers	Number (Percentage %) of CTs: Male	Female	Total
Descriptions of the students/Q15	Naughty	2 (17)	3 (38)	5 (25)	Well behaved	4 (33)	3 (38)	7 (35)
	Strong cogn. skills	**11 (92)**	**6 (75)**	**17 (85)**	Strong cogn. skills	2 (17)	1 (13)	3 (15)
	Weak person. traits	4 (33)	1 (13)	5 (25)	Positive person.traits	3 (25)	2 (25)	5 (25
					Efficient in school	**7 (58)**	**6 (75)**	**13 (65)**
	No idea			1 (5)				

Students' preferences. Half of the CTs (10) expressed *gender-neutral* beliefs stating that there is no differentiation between boys' and girls' preferences in CS, while the rest half (10) expressed *gendered beliefs* supporting that boys and girls have different preferences. In fact, they claimed that boys prefer more than girls hardware/software or every domain of CS, whereas girls just use technology. Most of the females (5) stated that they do not identify different preferences between boys and girls, and just a few (3) believe that males prefer hardware or/and software, and that females just use of technology (1). On the contrary, some of the male CTs (5) believe that boys do not have a specific preference as they appear adept at every aspect of CS, unlike girls who just select to use technology without being actually involved in CS (4).

Students' potential in CS. In fact, the majority of the CTs (14) expressed a *gendered* belief clearly in favor of boys arguing that males, compared to females, are more likely to study and pursue CS. Just a few (6) were *gender-neutral* giving a chance to females as well, mentioning that both males and females can have a future in CS

Students' way of learning. When the CTs were asked whether boys and girls learn CS in a different way, 5 of them (4 males and 1 female) expressed a gender-neutral belief saying that they believe that boys and girls do not learn in a different way. However, several gendered beliefs were expressed by the rest of the CTs stating that boys and girls learn differently. Regarding boys, some of the CTs believe that they learn through challenging activities (6; 3 male CTs and 3 female CTs) while for a few male teachers (4) boys learn through personal involvement beyond school time by trying things on their own. On the other hand, regarding girls, most of the female CTs (7) believe that they need extra effort, methodology, support and encouragement to be engaged to CS, in contrast to male teachers who believe that girls actually do not learn (4) and when they do, they need extra effort and support (3) mainly through theoretical school-courses (3). It seems that male and female CTs expressed different gendered beliefs in favor of one gender over the other; male CTs favored boys whereas female CTs acknowledged that girls need support and guidance.

Students' special characteristics regarding CS. Some of the CTs (6; 3 males and 3 females) reported *gendered neutral* beliefs that there are not different characteristics between boys and girls, arguing that they cannot recognize a pattern. Nevertheless, a considerable number of CTs (14) expressed gendered beliefs by arguing that male and females students have different characteristics concerning CS that may influence their preferences and performance. Some of the male teachers (3) believe that boys have the required high cognitive skills, such as mathematical and logical thinking, problem solving and algorithmically thinking, while others (7) highlighted males' confidence, persistence and interest in CS. On the contrary, the majority of male CTs (8) believe that females are diligent student –well behaved, pay attention in class, and study at home– but they are weak and insecure and need extra support, guidance, specific instructions, detailed methodology and extra time to perform well in CS courses (5). Regarding female CTs, half of them highlighted boys' confidence and persistence and just one mentioned their high cognitive skills. Concerning girls, some mentioned those characteristics that make them diligent students, others believe that females need support and guidance, while two mentioned persistence as a characteristic of females underlining an positive characteristic of females. It seems that, both male and female CTs hold gendered beliefs in favor of boys recognizing their strong cognitive capabilities and confidence while for girls they mostly acknowledge their diligence and discipline in the class as well as that they need support and guidance to succeed as CS students.

Attribution of students' incompetence. More than half of the CTs (14; 8 males and 6 females) believe that a possible bad performance of a boy in CS can be attributed to his general incompetence in school, mentioning that he may be a bad or an indifferent student. Five of the CTs, all of them males, stated that the bad performance of a boy can be attributed to the fact that he is not interested in CS and only 2 CTs (one male and one female) referred to the absence of the specific abilities needed in CS. Other factors mentioned were: lack of Computing experience, personal issues and bad behaviour. On the other hand, the majority of the CTs (13; 10 males, 3 females) claimed that the bad performance of a girl can be attributed to the lack of interest in CS. Actually, this is a common belief among male CTs, admitted by some of the female teachers as well. A few (3) claimed that a bad performance of a girl in CS courses can be explained by a general incompetence in school, while 2 male and 2 female teachers mentioned the lack of the specific abilities needed in CS. Other issues cited were: lack of Computing experience and personal issues beyond school. It seems that both male and female CTs expressed gendered beliefs by attributing a boy's incompetence mainly to his overall bad performance in school and secondarily to the lack of their interest in CS, while female's weakness to the lack of interest in CS.

Descriptions of the students. Closing this section, CTs were asked to describe boys and girls using adjectives. Apart from 1 female CT, every CT used one or more adjective to describe their students. Specifically, almost all of the CTs (17; 11 males and 6 females), used adjectives that highlight boys' high cognitive skills, such as 'smart', 'imaginative', 'vigorous', 'intellectual', 'flexible', 'problem-solver', 'decision maker', 'creative' while some CTs, mainly males, used adjectives highlighting some weak personality traits, like 'impulsive', 'spontaneous' and 'impatient' (5). Moreover, some of the CTs focused on boys' behaviour in class and described them as naughty students (5). As far as the girls are concerned, the majority of the CTs (13; 7 males and 6 females), mentioned their efficiency in school subjects, describing them as 'diligent', 'hard workers', 'good students', 'dedicated co-workers' (12), and some of them cited their good behaviour in class, 'respectful', 'nice', 'good manners' (6). It is worth mentioning though that just 2 males and one female CT referred to females' cognitive skills, characterizing them as 'smart' and 'creative' and 5 cited some positive personal traits, describing females as 'persistent' and 'patient'. It seems that both male and female CTs expressed gendered beliefs emphasizing on boys' high cognitive skills and girls' efficiency in school along with some positive personality traits that balance any cognitive disadvantage.

7.2.1.4 CTs' beliefs about gender issues in a Computing class. CTs' answers regarding their interactions with boys and girls (Q16: Could you describe the kinds of interaction between you and your boys and girls?) as well as their expectations from their students (Q17: What are your expectations for boys and girls?), their views about gender difference in a Computing class (Q18: In what ways do you think that gender differences might become visible in the class?) are reported in this section. The categories emerged from the CTs' answers to the aforementioned questions are presented in Table 24.

Table 24

Computing Teachers' beliefs about gender issues in a Computing class

Issue/Question	Interviews: Categories of CTs' answers		Number (Percentage %) of CTs		
			Male	Female	Total
Kind of interactions with students/Q16	Gender neutral regarding CS subject		**10 (83)**	**4 (50)**	**14 (70)**
	More with boys because of…	Behaviour	1 (8)	4 (50)	**5 (25)**
		Interest/abilities	2 (17)	1 (13)	3 (15)
	Interact more with girls giving extra time		2 (17)	1 (13)	3 (15)
Aspects of gender differences in Computing class/Q17	Performance and abilities		**6 (50)**	**3 (38)**	**9 (45)**
	Behaviour		3 (25)	2 (25)	5 (25)
	Competitiveness		3 (25)	1 (13)	4 (20)
	Composition of the teams		4 (33)	**3 (38)**	7 (35)
	Participation in class		2 (17)	2 (25)	4 (20)
	Stereotypes about girls' abilities		2 (17)	2 (25)	4 (20)
	No idea		1 (8)	1 (13)	2 (10)
Expectations from students/Q18	Gender neutral		**9 (75)**	**5 (63)**	**15 (75)**
	More from boys		3 (25)	2 (25)	5 (25)
	Support girls		2 (17)	0 (-)	2 (10)
	No expectations		0 (-)	1 (13)	1 (5)

Interactions with students. Most of the CTs (14; 10 male and 4 female) CTs stated that they try to be *gender-neutral* concerning their interactions with their students in the Computing class. A few male CTs mentioned that they interact more with boys because of behaviour issues (1) or their interest and abilities in CS (2) while just a few claimed that they are more patient with females (2) giving them more time. For female

CTs different interaction are mainly triggered by the bad behavior of boys (4). In the end, it seems that mainly both male and female CTs content that they do not interact differently with boys and girls within the CS class.

Gender differences in a Computing class. All but one male and one female CT - who had no idea- mentioned several aspects of gender differences in Computing classes. Some of the CTs expressed some *gendered beliefs* favoring boys or girls. In fact, some CTs (6 males and 3 females) mentioned differences in abilities and skills between boys and girls implying that boys outperform girls. Other CTs (3 males and 2 females) stated that boys' and girls' behaviour in class differs, implying that girls are well-behaved compared to boys who are naughty and disobedient. Students' tendency to form single-gender groups in computer labs was also mentioned by both male and female CTs (4 and 3 respectively), as an aspect of gender differentiation in Computing classes. Competitiveness between boys and girls in the Computing class seem to be highlighted by some of the male CTs (3), while a few male (2) and female (2) CTs recognized that the stereotypes about low females' abilities in CS are mainly expressed by boys.

Expectations from boys and girls. Most of the CTs (15; 9 male and 5 females) expressed a *gender-neutral belief* stating that they have the same expectations from boys and girls. Some of the CTs expressed some *gendered beliefs*: a few male CTs (3) claimed that they expect more from boys because of their abilities and skills in CS and others (2) mentioned that they tend to support girls because they feel them weak. Only 2 of the female CTs argued that they expect more from boys. It seems that the majority of the CTs state that they are gender neutral regarding their expectations from their students.

7.2.1.5 CTs' beliefs about gender differences in CS and the CTs role. Teachers' beliefs regarding the existence or not of gender differences in CS (Q19: What is your opinion on gender differences in CS?), the severity of the problem (Q20: Do you consider it a problem?) their role in encouraging or discouraging the gender gap (Q21: Could you recall any situations in which you encourage/discourage (intentionally or accidentally) the gender gap in CS?) as well as the prior consideration of gender issues (Q23: Before this interview, did you plan your lesson considering gender issues?) are reported in this section. Table 25 presents the categories come out of the CTs' answers in the abovementioned questions.

Existence of gender differences. All of the CTs, apart from one male and one female, expressed gender-sensitive beliefs claiming that there are actual gender differences in CS. In fact, one male CT stated that there are not gender differences in CS, while one female had no opinion. In that sense, it seems that most of the interviewed CTs are aware of the gender differences in CS.

Table 25

Computing Teachers' beliefs about gender differences in CS and their role

Issue/Question	Interviews: Categories of CTs' answers		Number (Percentage %) of CTs		
			Male	Female	Total
Existence of gender differences/Q19	Yes		**11 (92)**	**7 (88)**	**18 (90)**
	Not		1 (8)	-	1 (5)
	No idea		-	1 (13)	1 (5)
Gender gap as a problem/Q20	Yes		3 (25)	**5 (63)**	8 (40)
	No		**9 (75)**	2 (25)	**11 (55)**
	No idea		-	1 (13)	1 (5)
Encourage or discourage the gender gap in CS/Q21	Discourage the gender gap		1 (8)	2 (25)	3 (15)
	Neutral		**6 (50)**	**3 (38)**	**9 (45)**
	Encourage	Consciously	1 (8)	1 (13)	2 (10)
		Unconsciously	4 (33)	2 (25)	6 (30)
Prior consideration of gender issues/Q22	Yes		3 (25)	**6 (75)**	9 (45)
	No		**9 (75)**	2 (25)	**11 (55)**

Gender gap as a problem. A considerable number (11) of the CTs expressed a gender-insensitive belief stating that gender gap in CS is not a problem. Most male CTs agreed with this opinion (9), while the majority of the females (5) expressed a gender-sensitive belief arguing that gender gap is an actual problem that has to be challenged.

Encourage/discourage gender gap. Some of the CTs (9) expressed *gender-neutral beliefs* stating that they cannot recall any situation where they encouraged or discouraged the gender gap, others (6) claimed that maybe unconsciously had encouraged the perpetuation of the gender gap and a few expressed *gender-sensitive* beliefs claiming that they have tried to redress existing gender inequalities. Specifically, half of the male CTs (6) stated gender-neutral beliefs while others (4) stated that maybe unconsciously have reinforced the gender gap. Just one male CT said that consciously has tried to dispel the myth while another one stated that he encouraged the gap consciously, as he has encouraged boys believing that they have a chance to succeed in CS. On the other hand, some of the female CTs (3) claimed that they were gender-neutral so far, while others (3) supported that they may have encouraged the gender gap, consciously or unconsciously. Finally, two of the female CTs stated that they have tried to discourage the gap and dispel the myths and the stereotypes within the field.

Prior consideration of gender issues. Most of the CTs (11) claimed that they had not even considered gender issues during teaching until this interview, while the rest (9) expressed a *gender sensitive* belief stating that they had adjusted their teaching practices taking into consideration gender issues. Nevertheless, it seems that there is a different approach between male and female CTs. Most of the male CTs (9) stated that they hadn't thought of gender issues before and they are not willing to change their mind and start thinking gender issues during lesson planning. On the contrary, most of the female CTs (6) expressed a *gender-sensitive* belief and stated that they are willing to contribute to the narrowness of the gender gap in CS.

7.2.2 Computing Teachers' Practices

This section presents the results of the analysis of the data regarding CTs' practices in the scope of the four major analysis axes of analysis presented previously. Firstly, the results from the analysis of the number of interactions between CTs and students are presented along with the categories of CTs concerning the frequency of interactions with girls/boys (section 7.3.1.1). Secondly, the data regarding the type of the interactions as well as the level of questioning between the CT and girls/boys are reported, and the categories of CTs regarding the level of questions addressed to girls/boys are introduced (section 7.3.1.2). Thirdly, data regarding the type of the verbal feedback given by the CTs are displayed by categorizing the CTs depending on whether they differentiate the feedback they give to their students because of their gender (section 7.3.1.3). Finally, the data concerning the non-verbal behavior of the CTs in terms of wait time and physical closeness are introduced (section 7.3.1.4)

For Table 26 to Table 46, the first column refers to the CT [CTi (i=1,…,20)] along with her/his gender (F=female, M=male), while for the next columns, in each cell the first number refers to frequency and the number in the parenthesis to the corresponding percentage.

7.2.2.1 Interactions between CTs and girls/boys. This section presents the frequency and the percentage of CT-student interactions in terms of interactions initiated by the CT and interactions with girls and boys overall. For the purpose of this study the following assumptions were made: CTs who address question to the whole class in percentages more than 75% is considered to initiate interactions mainly with the whole class; CTs who initiate interactions, or interact overall, with boys and girls in percentages that differ less than 15% is considered that they interact with girls and boys equally; CTs who initiate interaction, or interact overall, with students of one gender over the other in percentages that differ more than 15%, is considered to interact more with girls or boys depending on the percentage that prevails.

Regarding the frequency and the percentage of interactions between the CTs and girls/boys, the data analysis revealed 3 categories of CT-student interactions, and specifically, CTs who interacted: (a) equally with girls and boys, (b) more with boys compared to girls, and (c) more with girls compared to boys.

(a) CTs who interacted equally with girls and boys (neutral). The CTs who drop into this category *initiated* interactions mainly with the whole class or with boys and girls in comparable percentages (Table 26; columns 5, 6) and overall interacted equally with girls and boys (Table 26; columns 2, 3) *(neutral)*. As it is shown in Table 26, a considerable number of CTs, 4 males and 3 females, seem to be neutral concerning the initiation of interactions to girls and boys as well as their overall interactions with girls and boys.

Table 26

CTs interacting equally with boys and girls (neutral)

Computing Teacher	Total interactions between the CT and…			Interactions initiated by the CT addressed to…		
	Girl	Boy	Group	Girl	Boy	Class
CT01 (M)	20 (41)	20 (41)	9 (18)	1 (4)	4 (17)	18 (78)
CT07 (M)	30 (37)	41 (50)	11 (13)	17 (27)	10 (16)	37 (58)
CT08 (M)	43 (48)	35 (39)	12 (13)	3 (5)	7 (12)	50 (83)
CT10 (M)	21 (46)	17 (37)	8 (17)	-	1 (6)	15 (94)
CT15 (F)	30 (52)	21 (37)	6 (11)	7 (17)	10 (24)	24 (59)
CT17 (F)	22 (41)	20 (38)	11 (21)	12 (26)	13 (28)	22 (47)
CT19 (F)	32 (49)	29 (45)	4 (6)	18 (47)	13 (34)	7 (18)

(b) CTs who overall interacted more with boys (boys / n-boys). The second category of CTs regarding the frequency of interactions with girls and boys are those CTs who *overall interacted* more with boys. Those teachers are divided into two sub-categories, those CTs who:

i. *initiated more interactions with boys* compared to girls (Table 27; columns 5, 6), and overall interacted more with boys (Table 27; columns 2, 3) (boys), and

ii. *addressed questions mainly* to the whole class (Table 28; column 4) or initiated interactions with boys and girls equally (Table 28; columns 5, 6) but overall interacted more with boys (Table 28; columns 2, 3), as boys answered more questions addressed to the class or boys initiated more interactions with the CT (*n-boys*).

Table 27

CTs interacting more with boys, initiating more interactions to boys (boys)

Computing Teacher	Total interactions between the CT and…			Interactions initiated by the CT addressed to…		
	Girl	Boy	Group	Girl	Boy	Class
CT04 (M)	23 (31)	36 (49)	15 (20)	5 (9)	22 (39)	30 (53)
CT05 (M)	23 (34)	37 (54)	8 (12)	2 (6)	20 (63)	10 (31)
CT12 (M)	17 (26)	41 (63)	7 (11)	2 (4)	27 (56)	19 (40)
CT18 (F)	10 (17)	34 (58)	15 (25)	1 (3)	16 (40)	23 (58)

As it is shown in Table 27 and Table 28, mainly *male CTs* interacted more with boys. In fact, three male CTs and one female CT *initiated* more interactions with boys, while another three male CTs and one female CT even though they were neutral regarding the initiation of the interactions, they interacted more with boys *overall*.

Table 28

CTs neutral concerning the interactions initiated by them, interacting more with boys overall (n-boys)

Computing Teacher	Total interactions between the CT and…			Interactions initiated by the CT addressed to…		
	Girl	Boy	Group	Girl	Boy	Class
CT03 (M)	22 (24)	50 (56)	18 (20)	4 (8)	19 (38)	27 (54)
CT06 (M)	16 (24)	36 (53)	16 (24)	9 (20)	2 (4)	35 (76)
CT11 (M)	7 (18)	24 (63)	7 (38)	1 (4)	4 (15)	22 (81)
CT16 (F)	16 (27)	36 (60)	8 (13)	13 (30)	16 (37)	14 (33)

(c) CTs who interacted more with girls (girls / n-girls). The CTs who interacted *overall* more with girls compared to boys constitute the third category of CTs. Those CTs who:

i. *initiated more interactions with girls* compared to boys (Table 29; columns 4, 5), and overall interacted more with girls (Table 29; columns 2, 3), *(girls)* and

ii. *addressed questions mainly to the whole class* (Table 30; column 7) or they initiated interactions with boys and girls equally (Table 30; column 5, 6) but overall interacted more with girls (Table 30; column 2, 3), as girls answered more questions addressed to the class or girls initiated more interactions with the CT (n-girls).

Table 29

CTs interacting more with girls initiating more interactions with girls (girls)

Computing Teacher	Total interactions between the CT and…			Interactions initiated by the CT addressed to…		
	Girl	Boy	Group	Girl	Boy	Class
CT09 (M)	**35 (56)**	10 (16)	17 (27)	8 (15)	-	47 (85)
CT14 (F)	**43 (72)**	12 (20)	5 (8)	19 (38)	3 (6)	28 (56)
CT20 (F)	**33 (41)**	45 (56)	2 (3)	22 (40)	11 (20)	22 (40)

As it is shown in Table 29 and Table 30, mainly female CTs interacted more with girls compared to boys. Actually, three females and two male CTs, interacted overall more with girls, while two females and one male from those teachers initiated more interactions with girls.

Table 30

CTs neutral concerning the interactions initiated by them, interacting more with girls overall (n-girls)

Computing Teacher	Total interactions between the CT and…			Interactions initiated by the CT addressed to…		
	Girl	Boy	Group	Girl	Boy	Class
CT02 (M)	32 (52)	10 (16)	17 (28)	4 (9)	5 (11)	**38 (81)**
CT13 (F)	55 (64)	8 (10)	21 (25)	5 (8)	3 (5)	**54 (87)**

7.2.2.2 Types of interactions and level of questioning. The interactions recorded between CTs and girls/boys were of two types: conduct and intellectual. *Conduct* concerns student behavior while intellectual interactions could be of *low* (knowledge level questions) or *high intellectual level* (analysis/evaluation questions). For this analysis, conduct and low level intellectual questions are considered *low level* *interactions*, while high level intellectual questions are considered *high level interactions*. When the percentage of the CT-student interactions of a specific level is over 75% it is considered that CT-student interactions were *mainly* of that level. CT-student interactions are considered *mix* when neither low nor high level CT-student interactions exceed 75%.

Keeping this acceptance in mind, the data analysis uncovered three types of CTs. Those CTs who: (a) follow the *same pattern* regardless of the gender of the student, interacting with girls and boys either mainly through low level interactions *(low)*, or a mix of low and high level interactions *(mix)*, (b) interact with girls through a mix of low and high level questions and with boys mainly through low level questions *(g_mix/b_low)*, and (c) interact with girls through low level questions while with boys through a mix of low and high level questions *(g_low/b_mix)*.

(a) CTs who interact with girls and boys through the same level of questioning (low or mix). Some of the CTs interacted with girls and boys through the same level of questioning and are divided further into two sub-categories. Those CTs who:

i. *interacted with girls and boys mainly through low level interactions (low):* Three males and one female CT, interacted with girls and boys mainly though low level questioning (low) (Table 31; columns 3, 5, 6). Two of the males interacted with both girls and boys exclusively through low level questions. The only female CT interacted mainly through low level questions with girls while almost half of her interactions with boys concerned their behaviour in class.

ii. *interacted with girls and boys through a mix of low and high level interactions (mix):* One male and one female CT interacted with girls and boys though a mix of low and high level questions (mix). Both of them spent over 10% of their interactions with boys because of their behavior in class (Table 32).

Table 31

Low level questions to girls and boys (low)

Computing Teacher	Type of Interaction with…					
	girls			boys		
	Conduct	Intellectual / Level Of Question		Conduct	Intellectual / Level Of Question	
		Low	High		Low	High
CT06 (M)	-	13 (81)	3 (19)	-	33 (92)	3 (8)
CT08 (M)	-	43 (100)	-	-	35 (100)	-
CT09 (M)	-	35 (100)	-	-	10 (100)	-
CT17 (F)	-	20 (91)	2 (9)	8 (40)	12 (60)	-

As it is shown in Table 31 and Table 32, one third of the CTs did not differentiate the level of questions addressed to their students because of their gender, while when their interactions with the students was of conduct type, the other participant in the interaction was exclusively boy.

Table 32

Mix of low and high level questions to girls and boys (mix)

Computing Teacher	Type of Interaction with…					
	girls			boys		
	Conduct	Intellectual / Level Of Question		Conduct	Intellectual / Level Of Question	
		Low	High		Low	High
CT01 (M)	-	14 (70)	6 (30)	3 (15)	12 (60)	5 (25)
CT16 (F)	-	11 (69)	5 (31)	4 (11)	20 (56)	12 (33)

(b) CTs who interact through a mix level questions with girls and mainly through low level questions with boys *(g_mix/b_low).* The CTs who belong in this category interacted with girls though a mix of low and high level questions while with boys mainly through low level questions and/or conduct *(g_mix/b_low)* (Table 33; columns 3, 4, 5, 6, 7). A considerable number of CTs (7 CTs) fall into this category. In fact, there are 2 male and 2 female CTs who interacted with boys mainly through low level questions (Table 33; columns 6, 7), while 3 female CTs apart from low level questions interacted with boys trying to discipline them (Table 33; column 5). On the other hand, the interactions of these 7 CTs with the girls were a mix of low and high level, while in some cases (CT02, CT07, CT19) teacher-girl high level interactions outnumbered low level ones **(**Table 33; columns 3, 4**).**

(c) CTs who interact mainly through low level questions with girls and a mix of low and high level questions with boys *(g_*low/b_mix*)*. There were some CTs whose interactions with girls were mainly of low intellectual level while when they interacted with boys a mix of low and high level questions was employed (*g_*low/b_mix) (Table 34; columns 3, 4, 5, 6, 7). Interestingly, this category of CTs is mainly composed of male CTs.

Table 33

Mix of low and high level question to girls/low level to boys (g_mix/b_low)

Computing Teacher	Type of Interaction with…					
	girls			boys		
	Conduct	Intellectual / Level Of Question		Conduct	Intellectual / Level Of Question	
		Low	High		Low	High
CT02 (M)	-	11 (34)	21 (66)	-	8 (80)	2 (20)
CT07 (M)	-	11 (37)	19 (63)	-	33 (80)	8 (20)
CT13 (F)	-	40 (73)	15 (27)	1 (13)	7 (87)	-
CT14 (F)	-	29 (67)	14 (33)	-	12 (100)	-
CT15 (F)	-	21 (70)	9 (30)	6 (29)	14 (67)	1 (5)
CT19 (F)	-	14 (44)	18 (56)	4 (14)	22 (76)	3 (10)
CT20 (F)	-	18 (55)	15 (45)	-	38 (84)	7 (16)

As it is shown in Table 33 and Table 34, most of the female CTs interacted with girls through a mix of low and high level questioning while their interactions with boys were of low level. On the other hand, half of the male CTs chose to interact with girls through low level questions, while regarding boys, their interactions were a mix of low and high level questions.

Table 34

Low level questions to girls/mix of low and high level to boys (g_low/b_mix)

Computing Teacher	Type of Interaction with…					
	girls			boys		
	Conduct	Intellectual / Level Of Question		Conduct	Intellectual / Level Of Question	
		Low	High		Low	High
CT03 (M)	-	18 (82)	4 (18)	7 (14)	31 (62)	12 (24)
CT04 (M)	-	20 (87)	3 (13)	6 (17)	19 (53)	11 (31)
CT05 (M)	-	23 (100)	-	-	24 (65)	13 (19)
CT10 (M)	-	20 (95)	1 (5)	-	10 (59)	7 (41)
CT11 (M)	-	7 (100)	-	-	11 (46)	13 (54)
CT12 (M)	-	16 (94)	1 (6)	3 (7)	30 (73)	8 (20)
CT18 (F)	-	10 (100)	-	-	24 (71)	10 (29)

7.2.2.3 Feedback to girls/boys. The third dimension of the CT-student interactions analysis concerns the type of verbal feedback given by the teacher: positive (acceptance, praise, or enabling), negative (judgmental), or neutral (no feedback).

For this part of analysis, Table 35, Table 36 and Table 37 present the frequency and percentage of positive (cumulatively acceptance, praise, and enabling), negative and neutral feedback that CTs gave to girls and boys. CTs who gave positive feedback over 75% is concerned that they give *mainly positive* feedback; CTs who gave all kinds of feedback, each lower than 75%, is considered that they gave a *mix* feedback; CTs who gave neutral feedback over 50% is considered that they gave *neutral* feedback.

The data analysis uncovered 3 types of feedback that CTs gave to girls and boys, namely: (a) the *same of type of feedback* to girls and boys, mainly positive (positive) (Table 35) or a mix of positive, negative and neutral feedback (mix) in comparable percentages (less than 15%; see Table 36), (b) mainly positive feedback to girls and a mix feedback to boys (g_positive/b_mix) (Table 37), and (c) neutral feedback to girls and mainly positive to boys (g_neutral/b_positive) (Table 38).

(a) CTs who gave same feedback to girls and boys (positive or mix). The majority of the CTs gave the same kind of feedback to girls and boys. These CTs are divided further into two sub-categories. Those CTs who gave:

i. positive feedback to girls and boys (positive): Half of the CTs gave mainly positive feedback to both girls and boys (Table 35; columns 2 and 5). Specifically, 6 male CTs and 4 females explicitly or implicitly gave positive feedback to the students of both genders.
ii. mix feedback to girls and boys (mix): One male and one female teacher (CT16) responded to their students giving all the three types of feedback (Table 36; columns 2 to 7). Nevertheless, both of them gave mostly positive feedback.

Table 35

Similar (Positive) feedback to girls/boys

Computing Teacher	Teacher feedback to…					
	girls			boys		
	Positive	Negative	Neutral	Positive	Negative	Neutral
CT02 (M)	29 (91)	-	3 (9)	10 (100)	-	-
CT03 (M)	18 (82)	-	4 (18)	42 (84)	8 (16)	-
CT06 (M)	13 (100)	-	-	32 (89)	-	4 (11)
CT08 (M)	40 (93)	3 (7)	-	33 (94)	2 (6)	-
CT09 (M)	34 (97)	-	1 (3)	10 (100)	-	-
CT12 (M)	14 (82)	-	3 (8)	36 (88)	3 (7)	2 (5)
CT13 (F)	51 (93)	-	4 (7)	7 (87)	1 (13)	-
CT14 (F)	43 (100)	-	-	10 (83)	-	2 (17)
CT18 (F)	8 (80)	2 (20)	-	31 (91)	-	3 (9)
CT20 (F)	33 (100)	-	-	40 (89)	-	5 (11)

Both Table 35 and Table 36 reveal that the majority of male and female CTs gave similar feedback to girls and boys, either mainly positive (of some kind) or a mix feedback. As it is shown in Table 35, half of the male and half of the female CTs gave mainly some kind of positive feedback to both girls and boys.

Table 36

Similar (Mix) feedback to girls/boys

Computing Teacher	Teacher feedback to…					
	girls			boys		
	Positive	Negative	Neutral	Positive	Negative	Neutral
CT01 (M)	13 (65)	3 (15)	4 (20)	13 (65)	5 (25)	2 (1)
CT16 (F)	26 (72)	3 (8)	7 (19)	8 (50)	2 (13)	6 (37)

(b) CTs who gave positive feedback to girls and mix to boys (g_positive/b_mix). The five CTs (2 males and 3 females) who fit in this category gave mainly positive feedback to girls and a mix of positive, negative and neutral feedback to boys *(g_positive/b_mix)* **(**Table 37; columns 2, 5, 6, 7). Those CTs responded mainly positively to girls' answers or questions, but their comments to boys, in some cases, went beyond making corrections on boys' work to clear disapproval (negative), or gave them no feedback (neutral) without implying in any way that their responses were appropriate or not.

Table 37

Positive feedback to girls/mix to boys

Computing Teacher	Teacher feedback to…					
	girls			boys		
	Positive	Negative	Neutral	Positive	Negative	Neutral
CT04 (M)	**22 (96)**	-	1 (4)	21 (58)	5 (14)	10 (28)
CT07 (M)	**27 (90)**	-	3 (10)	32 (78)	3 (7)	6 (15)
CT15 (F)	**30 (100)**	-	-	12 (57)	6 (29)	3 (14)
CT17 (F)	**20 (91)**	-	2 (9)	9 (45)	9 (45)	2 (10)
CT19 (F)	**32 (100)**	-	-	20 (69)	4 (14)	5 (17)

(c) CTs who gave neutral feedback to girls and positive to boys (g_neutral / b_positive). There are three male CTs that mainly gave no feedback to girls but positive feedback to boys (g_neutral/b_positive) (Table 38; columns 2, 4, 5). The frequencies of neutral feedback to girls and positive feedback to boys reveal that these CTs seem to be indifferent towards girls without answering or implying in any way that their responses were appropriate or not, while at the same time accepted boys' answers as appropriate, or made positive comments to them, as well as challenged them to think.

As it is shown in Table 37 and Table 38, mainly female CTs reacted positively to girls' answers or questions, while some of the male CTs were, in many cases, indifferent to girls, avoiding to provide them with any kind of feedback.

Table 38

Neutral feedback to girls/positive to boys

Computing Teacher	Teacher feedback to…					
	girls			boys		
	Positive	Negative	Neutral	Positive	Negative	Neutral
CT05 (M)	9 (39)	-	14 (61)	37 (100)	-	-
CT10 (M)	10 (48)	-	11 (52)	17 (100)	-	-
CT11 (M)	3 (43)	-	4 (57)	21 (88)	-	3 (12)

Teacher's positive feedback to girls/boys. It is worth examining the exact type of positive feedback they gave to their boys and girls, as there are crucial differences among the 3 kinds of positive feedback regarding the student encouragement, boost of their self-esteem, and reinforcement of student' performance.

As discussed above, different kinds of feedback have a different impact on students' learning, positive self-esteem, encouragement, motivation and participation in class (Hattie & Timperley, 2007). Teachers who provide feedback that enables students, make them think and learn from their mistakes and praise the substance of their work help them move the learning process along and enhance their self-esteem. Different kind of positive feedback seems to have a different effect on students (Hattie & Timperley, 2007).

The results concerning the three different kinds of positive feedback recorded in class observations (acceptance, praise, or enabling) are presented in this section in order to examine further the positive feedback that CTs who participated in this study gave to girls and boys.

For the purpose of the analysis, we suppose that CTs gave the same kind of positive feedback to girls and boys when the differences in percentages are lower than 15%. CTs who gave a kind of feedback (or accumulative different kinds of feedback) more than 75% are considered to give *mainly* this kind (or kinds) of feedback.

Keeping this assumption in mind, the analysis of the positive feedback of the teachers revealed that there are 3 categories of CTs. Those CTs who gave: (a) the same kind of positive feedback to girls and boys, mix (*mix*) or mainly acceptance (*acc*), (b) mainly acceptance and praise to girls and praise and enabling to boys *(g_acce.pra/b_pra.en),* and (c) mainly praise and enabling to girls and acceptance and praise to boys (*g_pra.en /b_acce.pra*)

(a) CTs who gave the same kind of positive feedback to girls and boys (mix or acc). Six of the CTs (five males and one female), gave a mix of acceptance, praise and enabling feedback to girls/boys (Table 39), while one female gave mainly acceptance feedback to girls/boys (Table 40).

Table 39

A mix of positive feedback to girls/ boys

Computing Teacher	CT positive feedback to…					
	girls			boys		
	Acceptance	Praise	Enabling	Acceptance	Praise	Enabling
CT01 (M)	4 (31)	4 (31)	5 (38)	3 (23)	5 (38)	5 (38)
CT02 (M)	3 (10)	18 (62)	8 (28)	1 (10)	5 (50)	4 (40)
CT06 (M)	6 (35)	7 (41)	4 (24)	13 (45)	13 (45)	3 (10)
CT08 (M)	22 (55)	18 (45)	-	15 (45)	18 (55)	-
CT09 (M)	13 (38)	21 (62)	-	5 (50)	5 (50)	-
CT16 (F)	6 (43)	3 (21)	5 (36)	12 (43)	10 (36)	6 (21)

As it is shown in Table 39 and Table 40 a considerable number of CTs (7) provided the same kind of positive feedback to both girls and boys.

Table 40

Mainly acceptance feedback to girls and boys

Computing Teacher	CT positive feedback to…					
	girls			boys		
	Acceptance	Praise	Enabling	Acceptance	Praise	Enabling
CT17 (F)	17 (85)	2 (10)	1 (5)	9 (100)	-	-

(b) CTs who gave acceptance and praise feedback to girls and praise and enabling to boys (g_acce.pra/b_pra.en). The second category of CTs refers to teachers who differentiated their positive feedback in favor of boys (Table 41). Six male and one female teacher gave mainly acceptance and praise feedback to girls, mostly by accepting girls' answers as appropriate or correct (acceptance) and just in a few cases giving praise and positive reinforcement to them (praise). On the other hand, those teachers mainly praised (praise) and challenged boys to think (enabling) more frequently compared to girls, supporting and empowering boys more than girls.

Table 41

Acceptance and praise to girls/praise and enabling to boys

Computing Teacher	CT positive feedback to…					
	girls			boys		
	Acceptance	Praise	Enabling	Acceptance	Praise	Enabling
CT03 (M)	12 (67)	5 (28)	1 (6)	6 (14)	29 (69)	7 (17)
CT04 (M)	14 (64)	5 (22)	3 (17)	3 (14)	8 (38)	10 (48)
CT05 (M)	6 (75)	2 (25)	-	7 (18)	13 (35)	17 (46)
CT10 (M)	10 (100)	-	-	2 (12)	9 (53)	6 (35)
CT11 (M)	3 (100)	-	-	-	14 (67)	7 (33)
CT12 (M)	14 (100)	-	-	6 (17)	15 (43)	13 (37)
CT18 (F)	5 (63)	3 (38)	-	6 (19)	15 (48)	10 (32)

(c) CTs who gave praise and enabling feedback to girls and acceptance and praise to boys (g_pra.en /b_acce.pra). On the other hand, one male and five female teachers *mainly* praised and empowered girls more frequently compared to boys (Table 42; columns 3, 4). Regarding their positive feedback to boys, those teachers *mainly* just accepted their answers implying that they were correct and, in few cases, they praised them (Table 42; columns 5, 6). It seems that these teachers with their feedback supported and encouraged girls more than boys.

Table 42

Praise and enabling to girls/acceptance and praise to boys

Computing Teacher	CT positive feedback to…					
	girls			boys		
	Acceptance	Praise	Enabling	Acceptance	Praise	Enabling
CT07 (M)	4 (14)	10 (36)	14 (50)	23 (66)	8 (23)	4 (11)
CT13 (F)	10 (20)	21 (41)	20 (39)	3 (43)	4 (57)	-
CT14 (F)	8 (19)	19 (44)	16 (36)	7 (100)	-	-
CT15 (F)	5 (17)	21 (70)	4 (13)	12 (100)	-	-
CT19 (F)	4 (13)	26 (81)	2 (6)	16 (80)	1 (5)	3 (15)
CT20 (F)	-	26 (79)	7 (21)	28 (70)	11 (28)	1 (3)

As it is shown in Table 41 and Table *42* half of the male CTs differentiated the positive feedback they gave to girls and boys, encouraging and enabling boys more frequently than girls, while half of the female CTs supported and empowered girls more frequently compared to boys.

7.2.2.4 Teacher non-verbal behavior. The non-verbal behaviour of the teacher reflects the ancillary behaviour of the teacher and is analyzed in terms of: (a) *wait time* and (b) *physical closeness*.

Wait time. When a CT posed a question to a student, or the whole class, she/he waited some time to get a response before asking another student the same question, assisting or providing additional information. For this study, when a CT gave adequate time to the students to provide a reply (waited at least 5 seconds for low level questions and 10 seconds for high level question) in more than 75% of the CT-student interactions it is considered that this CT mainly waited to get a response.

Taking this as a fact, all of the CTs participated in this study, *mainly* waited to get a response from their students providing adequate time to students for thinking and answering their low and high level intellectual questions before terminating the response opportunity (*wait*).

It seems that CTs did not differentiate their attitude, regarding the wait time, because of the gender of the student and provided the necessary time to get more thoughtful responses encouraging participation by both girls and boys.

Physical closeness. The physical position of the CT in the lab/class during an interaction with a student was also recorded throughout the observation. CT's position could be close to the student or away from her/him.

For this part of analysis, we consider that a CT is *close to a student* each time she/he moved towards or stood/sat next to them and *away from a student* each time she/he posed interacted with the student from the board/chair or was in another place in the class during interaction. Table 43, Table 44, Table 45 and Table 46 present the frequency and the percentage of the interactions that a CT was close or away from girls and boys in class. When a CT is away from, or close to, a student in more than 75% of the CT-student interactions it is considered that this CT is mainly away, or close, to students. When her/his position in class does not follow a clear pattern away from, or close to, students it is considered that he/she follows a mix pattern.

Taking that as a fact, the CTs were classified into three groups. Those CTs who: (a) did not differentiate their position because of student gender, and, either were mainly away from boys and girls posing question mostly from the board/chair (away), or followed a mix pattern without a clear intention to be close or away from girls/boys (mix), (b) were mostly close to girls and mostly away from boys (g_close/b_away), and (c) were mostly away from girls while, regarding boys, in some cases they were close to them and in some cases away from them (g_away/b_mix)

(a) CTs who did not differentiate their position in class because of student gender (away or mix). More than half of the male CTs (9 out of 12) and half of the females (4 out of 8) were gender neutral as far as their physical position in the class is concerned. These CTs are divided further into two sub-categories. Those CTs who:

i. chose to pose questions to girls and boys mainly from the board or their chair (away). Five male and two female CTs fall into this category (Table 43). The interactions between those CTs with their students were mainly verbal as they preferred to keep a distance from their students.

ii. followed a mix pattern regarding their physical position while interacting with girls/boys (mix). Three male and two female CTs chose to pose some questions to their students (girls and boys) from the board but in several cases they moved towards their students or stood next to them in an attempt to get close to them, support and encourage them (Table 44).

Table 43

Away from girls and boys

Computing Teacher	Non-verbal teacher behavior towards…			
	girls		boys	
	Close to	Away from	Close to	Away from
CT02 (M)	-	32 (100)	-	10 (100)
CT04 (M)	-	22 (100)	-	36 (100)
CT05 (M)	19 (83)	4 (17)	31 (84)	6 (16)
CT06 (M)	1 (6)	15 (94)	5 (14)	31 (86)
CT08 (M)	-	43 (100)	-	35 (100)
CT11 (M)	-	7 (100)	-	24 (100)
CT13 (F)	-	53 (100)	-	8 (100)
CT17 (F)	-	22 (100)	-	20 (100)

As it is shown in Table 43 and Table 44 the majority of the CTs did not differentiate their physical position in class when interacting with girls/boys. This may indicates that they did not try to support more males or females by moving more next to them guiding and encouraging them.

Table 44

A mix pattern for girls and boys

Computing Teacher	Non-verbal teacher behavior towards…			
	girls		boys	
	Close to	Away from	Close to	Away from
CT01 (M)	13 (65)	7 (35)	10 (50)	10 (50)
CT09 (M)	18 (51)	17 (49)	7 (70)	3 (30)
CT12 (M)	6 (35)	11 (65)	18 (44)	23 (56)
CT14 (F)	14 (33)	29 (67)	6 (50)	6 (50)
CT16 (F)	10 (63)	6 (37)	16 (44)	20 (56)

(b) CTs who were mostly close to girls and away from boys (g_close/b_away). There were 4 CTs, one male and three females, who were close to girls, mostly standing next to them or moving towards them, trying to help and encourage them. On the contrary, when they interacted with boys, they posed questions and gave feedback to them, either from a place in the lab away from them or from the board (Table 45).

Table 45

Close to girls and away from boys

Computing Teacher	Non-verbal teacher behavior towards…			
	girls		boys	
	Close to	Away from	Close to	Away from
CT07 (M)	24 (80)	6 (20)	10 (24)	31 (76)
CT15 (F)	23 (77)	7 (23)	3 (14)	18 (86)
CT19 (F)	24 (75)	8 (25)	4 (14)	25 (86)
CT20 (F)	25 (76)	8 (24)	9 (20)	36 (80)

***(c)* CTs who were mostly away from girls and mix from boys (g_away/b_mix).** On the other hand, two males and one female CTs, interacted with girls *mainly* from distance (Table 46; column 3), posing questions, answering or giving feedback from the board or their chair, while their interactions with boys did not follow a clear pattern regarding their position in class, and in some cases they chose to be close to boys and others away from them (Table 46; columns 4, 5)

As it is shown in Table 45 and Table 46 there are some CTs (7) whose behavior regarding their physical position in class indicated a different attitude and treatment of the students because of their gender.

Table 46

Away from girls/mix boys

Computing Teacher	Non-verbal teacher behavior towards…			
	girls		boys	
	Close to	Away from	Close to	Away from
CT03 (M)	4 (18)	18 (82)	18 (36)	32 (64)
CT10 (M)	4 (19)	17 (81)	8 (47)	9 (53)
CT18 (F)	2 (20)	8 (80)	15 (44)	19 (56)

7.2.3 Computing Teachers' Practices Profiles

Based on the analysis of the data under the scope of the four major analysis axes, the findings allow for five basic categories (Pi, i = 1,…5, see Table 47) of CT practices, namely: '*gender neutral'*, *gender neutral interaction initiation-favoring girls on the whole',* '*gender neutral interaction initiation-favoring boys on the whole'* , '*overall in favor of boys*', *'overall in favor of girls'*.

Each category of practice is discussed concerning the data relating to the analysis axes presented previously which are also briefly depicted in Table 47. The abbreviations used in Table 47 were explained in the relevant sections.

Table 47
CTs' Teaching Profiles based on their practices in class

Computing Teacher	Teacher / student interactions	Type of interaction with girls/boys	Teacher's feedback to girls/boys	Teacher's feedback to (positive) girls/boys	Non-verbal Teacher's behavior: Wait time girls/boys	Non-verbal Teacher's behavior: Physical closeness girls/boys
P1: Gender neutral						
CT01 (M)	neutral	neutral (mix)	neutral (mix)	neutral (mix)	neutral (wait)	neutral (mix)
CT06 (M)	n-boys	neutral (low)	neutral (positive)	neutral (mix)	neutral (wait)	neutral (away)
CT08 (M)	neutral	neutral (low)	neutral (positive)	neutral (mix)	neutral (wait)	neutral (away)
CT16 (F)	n-boys	neutral (mix)	neutral (mix)	neutral (mix)	neutral (wait)	neutral (mix)
CT17 (F)	neutral	neutral (low)	g_positive / b_mix	neutral (acc)	neutral (wait)	neutral (away)
P2: Gender Neutral Interaction Initiation - Favoring Girls on the Whole						
CT02 (M)	n-girls	g_mix / b_low	neutral (positive)	neutral (mix)	neutral (wait)	neutral (away)
CT07 (M)	neutral	g_mix / b_low	g_positive/b_mix	g_pra.en /b_acce.pra	neutral (wait)	g_close/b_away
CT13 (F)	n-girls	g_mix / b_low	neutral (positive)	g_pra.en /b_acce.pra	neutral (wait)	neutral (away)
CT15 (F)	neutral	g_mix / b_low	g_positive/b_mix	g_pra.en /b_acce.pra	neutral (wait)	g_close/b_away
CT19 (F)	neutral	g_mix / b_low	g_positive/b_mix	g_pra.en /b_acce.pra	neutral (wait)	g_close/b_away
P3: Gender Neutral Interaction Initiation - Favoring Boys on the Whole						
CT03 (M)	n-boys	g_low / b_mix	neutral (positive)	g_acce.pra / b_pra.en	neutral (wait)	g_away/b_mix
CT10 (M)	neutral	g_low / b_mix	g_neutral/b_positive	g_acce.pra / b_pra.en	neutral (wait)	g_away/b_mix
CT11 (M)	n-boys	g_low / b_mix	g_neutral/b_positive	g_acce.pra / b_pra.en	neutral (wait)	neutral (away)
P4: Overall in favor of boys						
CT04 (M)	boys	g_low / b_mix	g_positive/b_mix	g_acce.pra / b_pra.en	neutral (wait)	neutral (away)
CT05 (M)	boys	g_low/ b_mix	g_neutral/b_positive	g_acce.pra / b_pra.en	neutral (wait)	neutral (away)
CT12 (M)	boys	g_low / b_mix	neutral (positive)	g_acce.pra / b_pra.en	neutral (wait)	neutral (mix)
CT18 (F)	boys	g_low/b_mix	neutral (positive)	g_acce.pra / b_pra.en	neutral (wait)	g_away/b_mix
P5: Overall in favor of girls						
CT09 (M)	girls	neutral (low)	neutral (positive)	neutral (mix)	neutral (wait)	neutral (mix)
CT14 (F)	girls	g_mix / b_low	neutral (positive)	g_pra.en / b_acce.pra	neutral (wait)	neutral (mix)
CT20 (F)	girls	g_mix / b_low	neutral (positive)	g_pra.en / b_acce.pra	neutral (wait)	g_close / b_away

7.2.3.1 P1: Gender Neutral. The main characteristic of these CTs' practices is that, in essence, there were gender neutral regarding the initiation of interactions, the type of interactions, the verbal feedback they give to their students and their non-verbal behavior during their interactions with students. Actually, there are 3 male and 2 female CTs who match this profile and did not differentiate their practices because of student gender. They addressed questions mainly to the whole class or to boys and girls equally and interacted with girls and boys through the same level of questioning (mainly low or a mix of low and high level interactions). They provided similar feedback to girls and boys, either a mix of positive feedback (acceptance, praise and enabling), or a mix of positive, negative and neutral feedback. They did not differentiate their non-verbal behavior towards girls and boys giving adequate time to students of both genders to answer their low and high level questions, and while interacting with them either they preferred to be away from girls and boys posing questions and answering to their students' questions from the board or moved in the lab/class getting close to boys and girls equally.

7.2.3.2 P2: Gender Neutral Interaction Initiation - Favoring Girls on the Whole. CTs' practices that fall under this profile are characterized by gender neutrality regarding the initiation of interactions from the CT and differentiation in the types of CT-student interactions, verbal feedback provided by the CTs and non-verbal behavior of CTs during interactions in favor of girls. Two males and three female CTs who meet this profile's characteristics addressed questions mainly to the whole class or to boys and girls equally, but in some cases they interacted more with girls overall as girls answered more questions addressed to the class or girls initiated more interactions with the CT. Despite the gender neutrality regarding the initiation of interactions, these CTs chose to interact with boys either by criticizing their behavior in class or by engaging low level questions, while, on the other hand empowered girls by employing high level questions enhancing their logical and analytical skills. By praising and enabling girls more frequently compared to boys they enhanced their self-esteem and challenged them to think developing higher cognitive skills. In most cases they chose to be close to girls when interacting with them giving an extra motive for participation while it seems that they gave adequate time for thinking to both girls and boys.

7.2.3.3 P3: Gender Neutral Interaction Initiation - Favoring Boys on the Whole. This profile of CTs' practices is characterized by a neutrality in the initiation of interactions on the part of the CT but a differentiation in the type of the interactions, the verbal feedback and the non-verbal behavior that favors boys in particular. The three male CTs in this profile addressed questions mainly to the whole class or initiated interactions with boys and girls equally. Nevertheless, in some cases, they interacted more with boys overall because boys answered more questions addressed to the class or they initiate more interactions with the CT. Despite the fact that, those CTs were neutral regarding the initiation of interactions, the type of the interactions, their feedback to girls and boys and their non-verbal behavior revealed a different treatment towards girls and boys. In fact, these CTs interacted with girls employing low level questions but when they interacted with boys they attempted to empower them to reach to higher levels of reasoning skills using both low and high level questions. In most cases CTs' feedback to girls and boys is different as well, as CTs seemed to be indifferent to the girls avoiding to provide any kind of feedback, positive or negative, while at the same time they were supportive to boys offering some kind of positive feedback, either by accepting their answers as appropriate, or making positive comment, or challenging them to think. Even though they provided adequate time to both girls and boys to think and reply to their questions, those CTs' moves in class indicated that in most cases they chose to interact with boys standing next to them and providing an extra support and guidance.

7.2.3.4 P4: Overall in favor of boys. CTs' practices under this profile clearly favor boys over girls in terms of initiations of interactions, type of interactions, and verbal feedback. Three males and one female CT who fall into this profile addressed questions mainly to boys interacting with them through a mix of low and high level questions, while they interacted with girls only few times where low level questions were employed. Even though in some cases they gave positive feedback to girls and boys, a closer inspection reveals that different kinds of positive feedback were provided. They encouraged and reinforced boys more frequently than girls enhancing their self-esteem and challenging them to think. Nevertheless, they gave girls and boys enough time to think and provide a reply to their questions, and in most cases their moves in the lab/classroom showed a neutral attitude being away and close to girls and boys equally, apart from the female CT who was mainly away from girls and close to boys.

7.2.3.5 P5: Overall in favor of Girls. Here, CTs' practices favor girls concerning the initiation and types of interactions, as well as the verbal feedback given by the CTs. One male and two female CTs under this profile initiated more interactions with girls and in most cases they interacted with girls through a mix of low and high level questioning advancing their logical and analytical skills, while their interactions with boys were mainly of low level. Even though they provided mainly positive feedback to girls and boys, they praised and empowered girls more frequently compared to boys in an attempt to enhance girls' self-esteem and challenge them to think and develop higher cognitive skills. Regarding their non-verbal attitude, they provided enough time to girls and boys to give an answer while, one female CTs under this profile prefers to be close to girls more frequently compared to boys.

7.2.4 Computing Teachers' Teaching Profiles and Beliefs Expressed during Interviews

Each one of the *CTs' practices profiles*, is discussed along with certain beliefs expressed by the CTs who fall into the profile during the interviews, and specifically: (a) their beliefs about themselves as teachers as well as CS as a school subject and its teaching and learning; (b) their beliefs about boys and girls as well as gender issues in a Computing class; (c) their beliefs about general gender differences in CS and their role in encouraging/discouraging gender gap. In this section, CTs' beliefs are discussed under the scope of the characterization of the beliefs, namely: (a) *'empowering'* and *'constraining'* beliefs, (b) *'gender-neutral'* and *'gendered'* beliefs, (c) *'gender-sensitive' and 'gender-insensitive'* beliefs. The expressed beliefs of each of the CTs are presented in the following Tables (Table 48 to Table 52)

P1: Gender Neutral

P1-CTs' views about themselves as teachers as well as CS as a school subject and its teaching and learning. P1-CTs expressed a mix of constraining and empowering beliefs as far as their motivation, their self-expectations, their strengths and weaknesses, as well as the CS as a school subject and its teaching and learning are concerned (see

Table 48; sections *themselves as teachers* and *CS as a school subject and its teaching and learning*). Most of them seem to be constrained by their extrinsic motivation and the lack of self-expectations as CTs. However, they are empowered by their confidence in their teaching abilities but constrained by the lack of self-confidence in their CS skills. Most of them also expressed empowering beliefs regarding CS as a school subject highlighting the practical and the theoretical aspect of CS, emphasizing on the facilitating role of a CT who should employ group work project activities to support and guide students to the development of the needed high cognitive skills.

P1-CTs' views about Gender Issues in a Computing class. P1-CTs expressed several gender-neutral and gendered beliefs regarding their interactions with boys and girls, their expectations from their students and the existence of gender differences in a Computing class (see Table 48; section *gender issues in a Computing class*). Most of them expressed gender-neutral beliefs stating that they interact equally with boys and girls and that they have the same expectations from them. Nevertheless, almost all of them recognized that there are gender differences in Computing classes, by expressing in some cases gendered beliefs in favor of boys as they stated that boys perform better than girls, or by focusing on the single-gender teams that student prefer to form in CS labs.

P1-CTs' beliefs boys, girls and CS. Most of the P1-CTs expressed gender-neutral beliefs about boys'/girls' preferences in CS as well as their potential to study/pursue CS, attributing boys'/girls' incompetence in CS to the same factors (see Table 48; section boys/girls and CS). However, most them expressed some gendered beliefs recognizing that both girls and boys use technology in different ways; boys play computer games, girls exploit the social aspect of CS. In addition, most them identified girls' lack of confidence in CS as their main characteristic regarding CS while they described boys highlighting their strong cognitive skills and girls as efficient and diligent students.

P1-CTs' beliefs about gender differences in CS and CT role. Even though almost all of P1-CTs expressed a gender-sensitive belief recognizing that there are gender differences in CS, they appeared gender-insensitive stating that they believe that this is not an actual problem and admitting that they had not tried in any way to bridge the gender gap and had not taken into consideration gender issues during lesson preparations before.

Table 48

Beliefs of Computing teachers who fall into teaching profile P1: Gender neutral.

Issue	Teachers' beliefs about		CT01	CT06	CT08	CT16	CT17
Themselves as CT teachers							
Motivation	Intrinsic					+	+
	Extrinsic		+	+	+	+	
Self-expectations	Become better teacher		+				
	No expectations			+	+	+	+
Strengths & Weaknesses	Strength	Teaching		+		+	+
		CS	+		+		
	Weakness	Teaching	+		+		
		CS		+		+	+
CS as a school subject and its teaching and learning							
Characteristics of CS as a school subject	A mental tool				+		
	Theoretical & practical		+		+	+	
	Practical subject			+			+
	Computer use					+	
Role of CT	CT as a facilitator		+	+	+	+	
	Traditional role						
Appropriate teaching strategies	Project group work		+	+	+	+	
	Real life activities				+	+	
	Direct Teaching				+	+	
	Use of educ. software		+			+	
	No idea						+
Necessary competences	High cognitive skills		+	+	+	+	+
	Experience & interest		+			+	+
Gender Issues in a Computing class							
Interactions with students	Gender neutral		+	+	+	+	+
	More with boys					+	
Expectations from students	Gender neutral		+	+	+	+	
	More from boys						+
Aspects of gender differences in Computing class	Performance		+		+		
	Behaviour				+		
	Competitiveness				+		
	Single-gender teams			+		+	
	No idea						+
Gender differences in CS and CTs role							
Existence of differences	Yes		+	+	+	+	
	No idea						+
Gender gap as a problem	No		+	+	+	+	
	No idea						+
Role in gender gap	Neutral			+		+	+
	Encourage unconsciously		+		+		
Prior consid. gender issues	Yes					+	
	No		+	+	+		+

Issue	Teachers' beliefs about		CT01	CT06	CT08	CT16	CT17
Boys/girls and CS							
Students' interest	Boys	Computer games	+	+	+	+	
		CS				+	
	Girls	Social aspect of technology	+	+	+	+	
	No idea						+
Students' potential in CS	Boys more likely				+		
	Both		+	+		+	+
Students' preferences in specific domains of CS	Boys	All domains		+			
		Software				+	
	Girls: Use of technology			+	+	+	
	No differentiation		+		+		+
Students' way of learning	Boys	Challenging activities					+
		Personal involvement					
	Girls	Need effort/support	+				
		Through school					+
	No differentiation						
Students' special characteristics regarding CS	Boys: High cognitive skills			+			
	Girls	Diligent students	+				
		Insecure	+	+		+	
		Persistence					
	No differentiation				+		+
Attribution of students' incompetence	Boys	General incompetence			+	+	
		Not interested in CS	+				
		Lack of abilities		+			
		Other issues					
	Girls	General incompetence				+	
		Not interested in CS	+		+		
		Lack of abilities		+			+
Description of students'	Boys	Naughty			+	+	
		Strong cognitive skills	+	+	+	+	
		Weak person. traits	+				
	Girls	Well behaved			+	+	
		Strong cognitive skills		+		+	
		Strong person. traits	+			+	
		Efficient in school	+	+		+	
	No idea						+

P2: Gender Neutral Interaction Initiation – Favoring Girls on the Whole

P2-CTs' views about themselves as teachers as well as CS as a school subject and its teaching and learning. CTs fall into this profile expressed a mix of empowering and constraining beliefs regarding their motivations, their self-expectations, their strengths and weaknesses as well as CS as a school subject (see Table 49; sections themselves as teachers and CS as a school subject and its teaching and learning). All of them, both males and females, expressed extrinsic motives to become Computing teachers, but it seem that females are maybe empowered by their expectation to become better teachers whereas males may be constrained by the lack of self-expectations. All these CTs believe in their teaching abilities but feel insecure as regards their CS skills. All of them expressed empowering beliefs regarding the CS as a school subject as males stated that it may act as a mental tool and help students develop high cognitive skills while females emphasized on the theoretical and the practical dimension of the subject. All of them stressed diligence as one of the needed student competences to succeed in a CS course, while most of them highlighted a facilitating role for the CT but proposed a mix of empowering and constraining teaching strategies.

P2-CTs' views about Gender Issues in a Computing class. CTs in P2 expressed a variety of *gender-neutral* and *gendered* beliefs regarding gender issues in a Computing class (see Table 49; section gender issues in Computing class). All of them expressed gender neutral beliefs in terms of their expectations from boys and girls, while some of CTs claimed that they are also gender-neutral regarding their interactions with students of both genders. Other CTs expressed gendered beliefs by arguing that they interact more with boys because of their (bad) behavior, or more with girls because they would like to provide them with extra help by giving them extra time to think and by being more patient with them by adjusting the tasks to meet their cognitive needs. Most of them recognized that gender differences in Computing classes are expressed in several ways; in favor of boys emphasizing their good performance, abilities, and participation in the class, and in favor of females stressing their good behavior in the class, as well as against females mentioning negative stereotypes regarding their low mental capabilities in CS.

Table 49

Beliefs of Computing teachers who fall into teaching profile P2: Gender neutral interaction initiation – favouring girls on the whole

Issue	Teachers' beliefs about	CT02	CT07	CT13	CT15	CT19
Themselves as CT teachers						
Motivation	Intrinsic	+				
	Extrinsic	+	+	+	+	+
Self-expectations	Become better teacher			+	+	+
	No expectations	+	+			
Strengths & Weaknesses	Strength: Teaching	+	+	+	+	+
	Weakness: CS	+	+	+	+	+
CS as a school subject and its teaching and learning						
Characteristics of CS as a school subject	A mental tool	+	+	+		
	Theoretical & practical			+	+	+
	Practical subject		+			
	Computer use				+	
Role of CT	CT as a facilitator		+	+	+	
	Traditional role					+
	No idea	+				
Appropriate teaching strategies	Project group work			+		+
	Real life activities			+		
	Direct Teaching		+		+	
	No idea	+				
Student necessary competences	High cognitive skills	+	+			+
	Experience & interest		+	+		+
	Diligent students	+	+	+	+	+
Gender Issues in a Computing class						
Interactions with students	Gender neutral	+	+			
	More with boys (behaviour)				+	+
	More with girls (time/explanation)	+		+		
Expectations	Gender neutral	+	+	+	+	+
Aspects of gender differences in Computing class	Performance		+		+	+
	Behaviour		+		+	
	Competitiveness			+		
	Single-gender teams			+		
	Participation in class					+
	Stereotypes about girls' abilities				+	+
	No idea	+				

Issue		Teachers' beliefs about	CT02	CT07	CT13	CT15	CT19
Boys/girls and CS							
Students' interest	Boys	Computer games				+	
		CS		+			+
	Girls	Social			+	+	+
	No idea		+				
Students' potential in CS	Boys more likely		+	+			+
	Both can study and pursue CS				+	+	
Students' preferences in specific domain	Boys	All domains		+			
		Hardware				+	
	No differentiation		+		+		+
Students' way of learning	Boys	Challeng.					+
		Personal involve	+				
	Girls: Need effort/support				+	+	+
	No differentiation		+	+		+	
Students' special characteristics regarding CS	Boys	High cognitive skills					+
		Confidence, interest	+	+	+		+
	Girls	Diligent students					+
		Insecure	+				
		Persistence			+		+
	No differentiation					+	
Attribution of students' incompetence	Boys	General incompetence		+	+		+
		Other issues	+			+	+
	Girls	General incompetence				+	
		Not interested in CS		+			+
		Lack of abilities			+		
		Other issues	+				
Description of students'	Boys	Naughty				+	
		Strong cogn. skills		+	+		+
		Weak pers. traits	+				+
	Girls	Strong cogn. skills	+				
		Strong pers. traits			+		
		Efficient in school		+		+	+
Gender differences in CS and CTs role							
Existence	Yes		+	+	+	+	+
Gender gap as a problem	Yes		+		+	+	+
	No			+			
Role in gender gap	Discourage		+			+	
	Neutral			+			
	Encourage unconsciously				+		+
Prior consideration of gender issues	Yes		+	+		+	+
	No				+		

P2-CTs' beliefs about boys, girls and CS. Most of the CTs in this profile expressed several *gendered* beliefs regarding boys and girls in relation to CS but these beliefs were not favoring boys or girls exclusively (see Table 49; section boys/girls and CS). They acknowledged that boys and girls use technology in different ways; boys used computer games as well as attempt to actively get involved with CS through hands on activities or software modifications, while girls exploit some social aspects of technology. Most of CTs claimed that there is not a differentiation between boys' and girls' preferences in CS recognizing also that girls need an extra effort and support -by the CT- to succeed. They attributed positive characteristics to both boys and girls stating that boys are confident and interested in CS, and girls are diligent students and show patience, persistence and good behavior. They credited boys' and girls' incompetence in CS to different factors and most of them highlighted boys' strong cognitive skills and girls' diligence in school.

P2-CTs' beliefs about gender differences in CS and CT role. CTs in this profile expressed some common *gender-sensitive* beliefs about gender differences in CS and their role as teachers (see Table 49; section gender differences in CS and CT role). They admitted that there are gender differences in CS and most of them agreed that gender gap is an actual problem that needs to be addressed. Interestingly, some CTs stated that they have tried before to bridge the gap is some way, while others admitted that maybe unconsciously have encouraged it. Nevertheless, most of them declared that they had thought of gender issues before and have tried to take gender issues into consideration while planning their CS lessons.

P3: Gender Neutral Interaction Initiation – Favoring Boys on the Whole

P3-CTs' views about themselves as teachers and CS as a school subject as well as its teaching and learning. CTs fall into this teaching profile expressed mostly common constraining and empowering beliefs regarding their motivation, their self-expectations as well as the CS as a school subject and its teaching and learning (see Table 50; sections themselves as teachers and CS as a school subject and its teaching and learning). All of them seem to be constrained by their extrinsic motives to become CTs and the lack of self-expectations. Nevertheless, they appeared to feel really confident stating that they have no weaknesses. All of them expressed constraining beliefs regarding the nature of CS as a school subject stating that it is mainly programming or computer use while most of them were of the opinion that a CT enable, motivate, guide and support her/his students employing group work and real-life activities. Finally, all of them stated that students have to be really interested in CS and devote extra time to it, beyond school time in order to succeed.

P3-CTs' views about gender issues in a Computing class. CTs in this profile expressed mostly gendered beliefs in favor of boys regarding their interactions with students, their expectations from their students and the presence of gender difference in Computing classes (see Table 50; section gender issues in Computing class). Even though most of them claimed to be gender neutral concerning their interactions with their students, some admitted that in some cases they interact more with boys due to their behaviour or their advanced skills and abilities. Most of them expect more from boys and identify several aspects of gender differences in a Computing class, mostly in favor of boys, underlying their good performance and their participation in class.

P3-CTs' beliefs about boys, girls and CS. CTs' views in this profile revealed several gendered beliefs about boys and girls in relation to CS (see Table 50; section boys/girls and CS). All of them acknowledged that girls are interested in the social aspect of technology and are satisfied just by using it. On the other hand, these CTs stated that boys are actually involved in CS, either by playing computer games or by using hands-on experience, they are more engaged in CS having an incline in software or hardware as well as it is more likely for them to study and pursue a career in CS. Most of them believe that boys are really interested in CS feeling really confident and can actually learn through challenging and engaging activities, whereas girls are diligent students and learn CS within the school context, basically just to meet the requirements of the subject. Finally, most of the CTs attributed both girls' and boys' incompetence in CS mainly to their lack of interest in CS, and overall highlighted boys' strong cognitive characteristics and girls' good behaviour and diligence in school.

Table 50

Beliefs of Computing teachers who fall into teaching profile P3: Gender neutral interaction initiation – favouring boys on the whole

Issue	Teachers' beliefs about		CT03	CT10	CT11
Themselves as CT teachers					
Motivation	Extrinsic		+	+	+
Self-expectations	No expectations		+	+	+
Strengths & Weaknesses	Strength:	Teaching	+		
		CS		+	+
	Weakness: None		+	+	+
CS as a school subject and its teaching and learning					
Characteristics of CS as a school subject	Practical subject			+	
	Programming		+	+	+
	Computer use		+		+
Role of CT	Traditional role		+		
	CT as a facilitator			+	+
Appropriate teaching strategies	Direct Teaching		+		
	Project group work		+	+	
	Real life activities				+
Student necessary competences	Computer experience		+	+	+
	High cognitive skills			+	
	No idea				
Gender Issues in a Computing class					
Interactions with students	Gender neutral		+	+	
	More with boys because of their	behaviour	+		
		abilities			+
Expectations from students	Gender neutral		+		
	More from boys			+	+
Aspects of gender differences in Computing class	Performance/abilities			+	
	Competitiveness		+		
	Single-gender teams		+		
	Participation in class		+		+

Issue	Teachers' beliefs about		CT03	CT10	CT11
Boys/girls and CS					
Students' interest	Boys	Computer games		+	+
		CS	+		
	Girls: Social aspect of technology		+	+	+
Students' potential in CS	Boys is more likely		+	+	+
Students' preferences in specific domain	Boys	Software			+
		Hardware	+	+	
	Girls: Use of technology		+	+	+
Students' way of learning	Boys	Challenging activities			+
		Personal involvement		+	
	Girls	Do not learn actually	+		+
		Through school			+
Students' special characteristics regarding CS	Boys: Confidence, interest			+	+
	Girls: Diligent students		+		+
Attribution of students' incompetence	Boys	General incompetence	+		
		Not interested in CS		+	+
	Girls: Not interested in CS		+	+	+
Description of students'	Boys	Strong cognitive skills	+	+	+
		Weak personal. traits	+		
	Girls	Well behaved			+
		Efficient in school	+		
		General incompetence		+	
Gender differences in CS and CTs role					
Existence of gender differences	Yes		+		+
	No			+	
Gender gap as a problem	No		+	+	+
Role in gender gap	Neutral		+	+	
	Encourage consciously				+
Prior consideration of gender issues	No		+	+	+

P3-CTs' beliefs about gender differences in CS and CT role. CTs' beliefs about the existence of gender differences in the field and their views about their role as CTs reveal a gender insensitive perspective (see Table 50; section gender differences in CS and CT role). Even though most of them identify that there are gender differences in CS, they do not recognize it as a problem. Most of them stated that they believe that they were gender neutral so far, but all of them admitted that they had not considered gender issues before either regarding their lesson planning or the significance of their role in bridging the gender gap.

P4: Overall in favor of boys

P4-CTs' views about themselves as teachers, CS as a school subject and its teaching and learning. P4-CTs expressed several *constraining* and *empowering* beliefs regarding their motivation and self-expectations, as well as the CS as a school subject, the role of the CT, the appropriate teaching strategies and the needed competences for a student to succeed (see Table 51; sections themselves as teachers and CS as a school subject and its teaching and learning). Most of them are empowered by their intrinsic motivation to become CTs and their expectation to improve their teaching skills and become more efficient and better teachers. All of these CTs seem to be empowered by confidence in their CS skills, while half of them admitted that they feel that their teaching abilities are weak. Most CTs in this profile focused on the practical aspect of the CS as a school subject and stressed a facilitating role for the CT suggesting several empowering and constraining teaching strategies, namely: direct teaching in compulsory courses and a mix of project group work with real life, engaging activities employing educational software in elective courses. For most of them high cognitive skills and personal interest in CS are the needed competences for a student to succeed in CS courses.

P4-CTs' views about gender differences in a Computing class. P4-CTs expressed various *gender-neutral* and *gendered beliefs favoring boys* regarding their interactions with girls and boys in class, their expectations and the existence of gender differences in Computing classes (see Table 51; section *gender issues in a Computing class)*. Almost all of them supported that they are gender neutral concerning their interactions with their students, while two of the CTs stated that when they interact more with boys it is because of their extra interest in CS. Half of them claimed that they are gender neutral regarding their expectations from their students, while the other half admitted that they expect more from boys. Most of P4-CTs expressed gendered beliefs in favor of boys regarding gender differences in Computing classes focusing on differences in abilities and performance in CS courses, implying that males perform better than females. In a few cases they mentioned single-gender teams in the CS lab as a difference.

P4-CTs' beliefs about boys/girls and CS. P4-CTs hold mainly *gendered beliefs favoring boys* (see Table 51; section boys/girls and CS). Most of them stated that boys are engaged in computer games and CS while half of them argued that girls are just interested in the social aspect of technology. Even though half of them expressed a gender-neutral belief stating that there is no difference in the preferences of boys and girls in specific domains of CS, the other half stressed that boys have an incline to all domains of CS. All of them believe that boys are more likely to study CS and pursue a CS career and most of them stated that they learn though challenging activities stressing their high cognitive skills as their main characteristic in CS, while they attributed a boy's incompetence in CS to his general incompetence in school. On the other hand, when it comes to girls they just mentioned their diligence as students stating that they learn CS within the school context just to meet the requirements of the subject while they attributed their incompetence in CS to the lack of interest or lack of abilities. Finally, P4-CTs described boys attaching to them adjectives that feature their strong cognitive skills, while for girls they used adjectives highlighting their good behavior and their efficiency in school.

P4-CTs' beliefs about gender differences in CS and the role of the CT. CTs' views about gender differences and their role as teachers revealed a mix of gender sensitive and insensitive beliefs (see Table 51; section gender differences in CS and CT role). Even though they acknowledged that gender differences in CS exist, they do not recognize them as an actual problem. Half of them claimed that they were gender neutral so far, while the other half admitted that maybe unconsciously have reinforced the gender gap. Finally, half of them showed a gender sensitive profile stating that they have taken into account gender differences during their lesson planning and teaching in Computing classes, while the other half admitted that they had not considered gender issues in CS before.

Table 51

Beliefs of Computing teachers who fall into teaching profile P4: Clearly in favor of boys.

Issue	Teachers' beliefs about		CT04	CT05	CT12	CT18
Themselves as CT teachers						
Motivation	Intrinsic			+	+	+
	Extrinsic		+		+	
Self-expectations	Become better teacher		+	+	+	
	No expectations					+
Strengths & Weaknesses	Strength	Teaching		+		+
		CS	+	+	+	+
	Weakness	Teaching	+		+	
		None		+		+
CS as a school subject and its teaching and learning						
Characteristics of CS as a school subject	Mental tool			+	+	
	Practical subject		+	+	+	
	Practical + Theoretical					+
	Computer use		+			
Role of CT	Traditional role				+	
	CT as a facilitator		+	+		+
Appropriate teaching strategies	Direct Teaching		+		+	+
	Project group work		+	+	+	+
	Real life activities		+	+		+
	Exploitation of educ. software		+		+	+
Student necessary competences	High cognitive skills		+	+	+	+
	Experience & interest		+		+	+
	Diligent students					+
Gender Issues in a Computing class						
Interactions with students	Gender neutral		+	+		+
	More with boys (interest/abilities)				+	+
	More with girls (time)				+	
Expectations from students	Gender neutral		+	+		
	More from boys				+	+
Aspects of gender differences in Computing class	Performance		+		+	+
	Behaviour				+	
	Single-gender teams		+	+		+
	Stereotypes about girls' skills		+			

Issue	Teachers' beliefs about		CT04	CT05	CT12	CT18
Boys/girls and CS						
Students' interest	Boys	Computer games	+	+		
		CS			+	
	Girls	Social	+	+		
	No idea				+	+
Students' potential in CS	Boys more likely		+	+	+	+
Students' preferences in specific domain	Boys: all domains			+	+	
	No differentiation		+			+
Students' way of learning	Boys: challenging activities			+	+	+
	Girls	Do not learn		+	+	
		Need effort		+		+
		Through school	+			
Students' special characteristics regarding CS	Boys	High cognit. skills		+	+	+
		Confidence/interes			+	
	Girls	Diligent students		+	+	
		Insecure				+
	No differentiation		+			
Attribution of students' incompetence	Boys	General incompet.	+	+	+	+
		Not interested	+	+		
		Other issues	+			
	Girls	Not interestedinCS			+	+
		Lack of abilities	+	+		
Description of students'	Boys	Naughty			+	
		Strong cogn.skills	+	+	+	+
	Girls	Well behaved			+	+
		Strong personality traits		+		
		Efficient in school	+	+		+
Gender differences in CS and CTs role						
Existence	Yes		+	+	+	+
Gender gap as a problem	Yes		+			
	No			+	+	+
Role in gender gap	Neutral			+		+
	Encourage unconsciously		+		+	
Prior consideration of gender issues	Yes		+			+
	No			+	+	

P5: Overall in favor of girls

P5-CTs' views about themselves as teachers, CS as a school subject and its teaching and learning. P5-CTs' expressed beliefs regarding their motivation and self-expectations, as well as the CS as a school subject, the role of the CT, the appropriate teaching strategies and the needed competences for a student have some common points (see Table 52; sections themselves as teachers and CS as a school subject and its teaching and learning). All of them were intrinsic motivated to become CTs by their love to teach and want to develop their teaching skills and become more efficient teachers. Most of them are *empowered* by their confidence in their teaching skills while some of them acknowledged weakness in CS or teaching skills. All of them pointed out the theoretical and the practical feature of CS as a school subject and most of them agreed that a teacher should be facilitator in teaching and learning process. Nevertheless, they proposed a *mix of empowering and constraining beliefs* regarding appropriate teaching strategies and needed competences.

P5-CTs' views about gender issues in a Computing class. *P5*-CTs seem to agree in most of their views about their interactions with girls and boys in class, their expectations and the existence of gender difference in Computing classes (see Table 52; section gender issues in Computing class). They claimed that they are *gender neutral* regarding their interaction with their students, and in those cases they interact more with boys they do so because of their unacceptable behavior, whereas in some cases they interact more with girls as they want to help and support them. They stated that they have the same expectations from girls/boys, recognizing that girls, in some cases, need support and encouragement. They recognized that there are gender differences in CS courses, but the aspects they highlighted do not favor exclusively one gender over the other.

P5-CTs' beliefs about boys/girls and CS. P5-CTs expressed several common gendered beliefs regarding girls, boys and CS (see Table 52; section boys/girls and CS). They acknowledged that girls' prior interest in technology is its social aspect, while all of them stated that males are more likely to study/pursue a CS career. They argued that girls need more support and guidance to succeed in CS courses and acknowledged that girls are diligent students and, in some case, feel insecure. They attribute girls' and boys' incompetence in CS to different factors; when a boy does not perform well in CS usually does not perform well in school in general, while a girl's incompetence in CS is attributed to her lack of interest in CS. Overall, when they described their students, they emphasized on boys' strong cognitive skills and girls' good performance in school.

Table 52

Beliefs of Computing teachers who fall into teaching profile P5: Overall in favor of girls

Issue	**Teachers' beliefs about**	**CT09**	**CT14**	**CT20**
Themselves as CT teachers				
Motivation	Intrinsic	+	+	+
Self-expectations	Become better teacher	+	+	+
Strengths & Weaknesses	Strengths: Teaching		+	+
	Strengths: CS	+		
	Weakness: Teaching	+		
	Weakness: CS			+
	Weakness: None		+	
CS as a school subject and its teaching and learning				
Characteristics of CS as a school subject	Mental tool	+		
	Theoretical and practical	+	+	+
	Computer use	+		
Role of CT	Traditional role			+
	CT as a facilitator	+	+	
Appropriate teaching strategies	Direct teaching			+
	Project group work		+	
	Real life activities	+		
Student necessary competences	High cognitive skills	+	+	
	Experience & interest	+		
	Diligent students		+	+
Gender Issues in a Computing class				
Interactions with students	Gender neutral	+		+
	More with boys (behaviour)		+	+
Expectations from students	Gender neutral		+	+
	Support females	+		
Aspects of gender differences in Computing class	Behaviour			+
	Participation in class		+	
	Stereotypes about girls' abilities	+		

Issue	**Teachers' beliefs about**	**CT09**	**CT14**	**CT20**
Boys/girls and CS				
Students' interest	Boys: Computer games	+		+
	Girls: Social aspect of tech		+	+
Students' potential in CS	Boys is more likely to study	+	+	+
Students' preferences in specific domains of CS	Boys: Hardware			+
	Girls: Use of technology			+
	No differentiation	+	+	
Students' way of learning	Girls: need effort/support	+	+	+
Students' special characteristics regarding CS	Boys: Confidence, interest	+		
	Girls: Diligent	+		+
	Girls: Insecure	+		
	No differentiation		+	
Attribution of students' incompetence	Boys: General incompetence	+	+	+
	Boys: Other issues		+	
	Girls: Not interested in CS	+	+	+
Description of students'	Boys: Strong cognit. skills	+	+	+
	Girls: Diligent students	+	+	+
Gender differences in CS and CTs role				
Existence of gender differences: Yes		+	+	+
Gender gap as a problem: Yes		+	+	+
Role in gender gap	Discourage			+
	Neutral	+	+	
Prior consideration of gender issues	Yes		+	+
	No	+		

P5-CTs' beliefs about gender differences in CS and the role of the CT. P5-CTs' reflections on the existence of gender differences and their role as a CT mainly revealed gender sensitive beliefs (see Table 52; section gender differences in CS and CT role). All of them recognized that there are gender differences in the CS domain and that it is a serious problem. All but one P5-CTs stated that they have tried at least to be neutral even though maybe they unconsciously have encouraged the gender gap. Nevertheless, they disclosed that they were already aware of the problem and in the past they have taken into consideration gender issues in their lesson planning.

7.3 Study3: Review of Main Research Findings

This section presents a review of the main findings of '*Study3'* of this thesis within the context of the third aim of the thesis, and specifically in terms of: (a) CTs' gender-related beliefs (sub-aim 3.1), (b) CTs' gender-related practices (sub-aim 3.2) and (c) relationship between CTs' expressed beliefs and their actual practices in class (sub-aim 3.3). These findings are discussed next as a response to the research questions posed in the context of the abovementioned sub-aims.

7.3.1 Computing Teachers' Gender-related Beliefs (RQ3.1.i.)

7.3.1.1 CTs' personal experience, motivation and self-expectations. The CTs expressed several constraining and empowering beliefs regarding their motivation, their self-expectations and their strength and weaknesses, as well gender-neutral and gendered views about their experience as students. Most of the CTs expressed constraining beliefs: they were motivated by extrinsic motives, have no expectation as teaching professionals, mentioned gender-neutral experiences as students and feel weak in their CS skills. On the contrary, half of the CTs mentioned empowering beliefs such as: intrinsic motives, expectations to become better and more efficient teachers, confidence in their teaching abilities, while they recalled some gendered experiences from their school years.

In terms of CTs gender, it seems that most *male* CTs reported constraining beliefs: extrinsic motives, lack of self-expectations and weakness in their teaching capabilities. However, most of them were empowered by their confidence in their CS skills and recalled gender neutral experiences from their teachers. For most of *female* CTs empowering beliefs were expressed: intrinsic motivation to become CTs, expectation to develop as teachers and confidence in their teaching abilities. On the contrary, most female teachers mentioned that their deficiency in CS skill may constrain them. The majority of them also stated that back in school their teachers treated boys and girls in different ways.

7.3.1.2 CTs' beliefs about CS as a school subject as well as its teaching and learning. The CTs expressed various constraining and empowering beliefs regarding the characteristics of CS as a school subject, the role of the CT, the appropriate teaching strategies and the needed competences for a student to fulfill the requirement of a CS course. Most of them shared some of the following empowering views: highlighted the theoretical and the practical aspect of the CS subject, pointed out a facilitating role for the CT who needs to implement various teaching strategies based on modern learning theories, such as projects, group work and real-life activities and underlined the need for high cognitive skills from students. By contrast, there are those who are attached to some of the following constraining beliefs: focus only on the practical aspect of the CS subject, propose a more traditional role for the CT employing direct teaching and use of drill and practice software and emphasize on the diligence and the exclusive interest and personal engagement in CS beyond school time as the only competences for a student to succeed.

In terms of CT gender, even though some of the *male* CTs expressed a few constraining views; emphasizing on the practical aspect of CS subject, such as programming and simple computer use, or supporting that interest and experience beyond school time are the only needed capabilities for a student, most of them stressed several empowering beliefs. They acknowledged that CS may act as a mental tool and suggested that the CT needs to implement modern teaching strategies, such as group work with real life activities, taking over the role of the facilitator in the teaching process, assisting students to advance their high cognitive skills that are necessary for success. Most of the *female* CTs hold some of the following empowering beliefs: stated that CS subject has both theoretical foundations and practical dimension, the role of the CT should be to guide, support and assist students in learning for themselves employing group work activities and highlighted high cognitive skills as the needed competences for success.

Nevertheless, some expressed constraining beliefs: half of them underlined direct teaching as an effective approach for compulsory courses and most of them stated that a student needs to be diligent and study at home to succeed in a CS course in school.

7.3.1.3 CTs' beliefs about girls/boys and CS. It seems that CTs expressed several *gender-neutral* and *gendered* beliefs about their students and CS as a school subject. Specifically, a few of CTs shared some of the following gender-neutral beliefs: did not differentiated boys' and girls' interests and preferences in CS, their way of learning, their characteristics regarding CS, their competences/incompetence to succeed/not succeed in CS. Nevertheless, most of the CTs expressed some *gendered beliefs mostly in favor of boys*: (a) claimed that boys are interested in Computing games and, in some cases, attempt to get actively involved with CS feeling comfortable with every domain of CS, in contrast to girls who just prefer to use technology utilising its social aspect; (b) stressed that boys is more likely to study or pursue a career in CS; (c) highlighted boys' strong cognitive skills and confidence as opposed to girls' diligence and obedience admitting that girls need support and guidance; (d) attributed boys' incompetence in CS mainly to their overall bad performance in school and secondarily to the lack of their interest in CS while girl's weakness to the lack of interest in CS; (e) described boys emphasizing on their high cognitive skills unlike girls where they focused on their efficiency in school.

In terms of CT gender, it seems that most of the male CTs expressed some of the above mentioned g*endered beliefs in favor of boys*. On the other hand, even though some of the female CTs expressed several of the aforementioned gendered beliefs in favor of boys, it seems that in some cases they expressed *gender-neutral beliefs* stating that mainly, there are not different domain preferences within the CS field between boys and girl, acknowledged that girls need support and guidance and attributed to them some strong personality traits.

7.3.1.4 CTs' beliefs about gender issues in a Computing class. Most of CTs expressed *gender-neutral* beliefs regarding their expectations from their students as well as their interactions with boys and girls in class, while a few said that they interact more with boys firstly because of their behavior and secondary because of their increased interest. Nevertheless, almost all of them recognized different aspects of gender differences in Computing classes. Some of them expressed *gendered beliefs* favoring boys suggesting that they perform better, are more capable and participate more in class compared to girls. Other CTs mentioned differences that are related to their students' choices and specifically, the composition of the teams formed in the computer lab (single-gender teams), the competitiveness between boys and girls in the class, as well as the stereotypical beliefs about females' cognitive abilities expressed mainly by boys.

In terms of CT gender, it seems that most of the male CTs said that they use teaching strategies that could be characterized as *constraining* their students' learning in compulsory courses. Half of them also expressed the aforementioned *gendered beliefs in favor of boys* regarding gender differences in Computing classes. However, most of them expressed *gender-neutral* beliefs by stating that they try to interact equally with boys and girls and have the same expectations from all of their students. Most of the female CTs stated that they employ teaching strategies which could be characterized as *empowering* their students to actively engage in their learning and expressed *gender neutral beliefs* regarding their expectations from their students and their interactions with boys and girls. Just in a few cases they expressed some gendered beliefs favoring boys.

7.3.1.5 CTs' beliefs about gender differences in CS and the CTs role. Even though almost all of the CTs are aware of the gender differences in CS most of them do not recognize it as an actual problem that has to be addressed. Most of the CTs expressed *gender-neutral* beliefs stating that they have not encouraged or discouraged the gender inequalities in CS and admitted that they hadn't considered gender issues before.

In term of CT gender, most of the male CTs recognize the existence of gender differences in CS but they believe that this is not an actual problem. Half of them claimed that they were gender neutral and had not reinforced the gender gap while a few recognized that maybe unconsciously have encouraged gender inequalities in CS. Nevertheless, most of them admitted that they did not considered gender issues during teaching and they are not willing to change this. For female CTs the gender gap is an actual problem that has to be faced. Some of them claimed that they are gender neutral and a few stated that they have tried to dispel gender stereotypes taking into consideration gender issues while teaching.

7.3.2 Computing Teachers' Practices in terms of Verbal/Non-Verbal Interactions with Girls/Boys (RQ3.2.i)

The analysis of the CTs' practices in terms of CT-student interactions under the scope of the four major axes of study (see section 7.3.2) indicated that: (a) the frequency of CT-students interactions was classified as: (a.1) gender-neutral, (a.2) interacted more with girls, (a.3) interacted more with boys; (b) the level of questions addressed to their students based on their gender was classified as: (b.1) differentiated and (b.2) not differentiated; (c) the kind of feedback provided to the students was classified as: (c.1) same for girls and boys, (c.2) differentiated feedback offered to girls/boys; (d) CTs' non-verbal behavior was classified both according to the necessary time to receive responses from both girls and boys which was not differentiated, and their physical position in class when interacting with girls/boys which was (d.1) differentiated or (d.2) not differentiated.

7.3.2.1 Frequency of interactions between CT and girls/boys. Most of the CTs participating in this study were gender-neutral regarding the initiation of interaction with their students, as they initiated interactions mainly with the whole class or with boys and girls equally.

In terms of CT gender, half of the male CTs interacted overall more with boys addressing questions to them more frequently compared to girls. On the other hand, it seems that female CTs-students interactions did not follow a clear pattern as some of the female CTs were gender-neutral, some interacted more with boys and others more with girls.

7.3.2.2 Type of interactions and level of questioning. Most of the CTs differentiated the level of questioning to girls and boys, yet there is not a clear tendency in favor of students of one gender over the other.

In terms of teacher gender, it seems that there is a clear pattern for male and female CTs. It appears that *male CTs* addressed mainly low level questions to girls, while they tried to empower boys to reach higher levels of thinking by employing both low and high level questions. On the contrary, some of the *female* CTs interacted mainly with boys either by criticizing their behaviour in class or engaging low level questions, whereas they attempted to enhance girls' high cognitive skills by employing a mix of low and high level questions.

7.3.2.3 Teacher feedback to girls/boys. Most of the CTs were gender-neutral as they gave the same kind of feedback to girls/boys. They differentiated, though, the positive feedback they provided to their students.

In terms of teacher gender, even though the majority of the *male CTs* provided the same kind feedback to both girls and boys, some of them avoided giving girls any kind of feedback and at the same time they were supportive to boys, offering some kind of positive feedback to them. On the contrary, even though most of the female CTs supported girls giving them some kind of positive feedback, they criticized boys or gave no feedback at all to them.

7.3.2.4 Teacher non-verbal behavior. It seems that all of the CTs participated in this study waited to get a response from their students providing adequate time to them to think and answer their low and high level intellectual questions. Moreover, it seems that most of the CTs did not differentiate their physical position in class while they interacted with girls and boys. Nevertheless, there are some CTs, mostly females, who chose to be close to girls maybe in an attempt to support, guide and encourage them more than boys, while mainly they interacted with boys from a distance. On the other hand, a few CTs, mostly males, interacted with girls mainly being away from them, while in some cases they chose to be close to boys supporting and guiding them making them feel more important. The reasons for this different attitude towards girls and boys can be partly determined if this behavior is examined in correspondence with their beliefs as they emerged from the CTs' interviews.

7.3.2.5 Computing Teachers' Practices Profiles. The analysis of the CTs' practices revealed five main teaching profiles, namely: P1-'gender neutral', P2-'gender neutral interaction initiation-favoring girls on the whole', P3-'gender neutral interaction initiation-favoring boys on the whole', P4-'overall in favor of boys', P5-'overall in favor of girls'. The five CTs who fall into P1 profile were gender neutral regarding the initiation and the type of interactions, the verbal feedback they give to their students and their non-verbal behavior. Even though eight of the CTs were neutral regarding the initiation of interactions, five of them favored girls (P2 profile) and the others boys (P3 profile) on the whole, as they addressed different types of questions to girls/boys, provided different kind of feedback to them and chose to differentiate their physical position in class when interacting with them. As for the rest 2 profiles, four CTs favored boys (P4 profile) and three CTs favored girls (P5 profile) overall concerning the initiation and type of interactions as well as verbal feedback provided.

In terms of teacher gender, half of the male CTs favored boys over girls and more than half of the females favored girls on the whole. This apparent different treatment of girls/boys from many of the male and female CTs may stem from the different gender-related beliefs they hold.

7.3.3 Relationship between Computing Teachers' Expressed Gender-related Beliefs and Actual Practices (RQ3.3.i.)

7.3.3.1 Associations between Computing teachers' teaching profiles and expressed beliefs.

P1: Gender Neutral. All of the P1-CTs expressed mixed beliefs regarding themselves as teachers, CS as a school subject, gender differences in Computing classes, boys and girls in relation to CS, general gender differences in CS and their role in the perpetuation or the mitigation of the gender gap. Some of their beliefs could empower them to improve the quality of their teaching and help students develop their skills and abilities in CS, whereas other may constrain them. Moreover, their expressed gendered beliefs mainly in favor of boys and their insensitivity regarding the gender differences in CS may deter them from acting towards closing the gender gap.

P2: Gender Neutral Interaction Initiation – Favoring Girls on the Whole. P2-CTs expressed both constraining and empowering beliefs about themselves as CTs and CS as a school subject that may influence their teaching practices. Even though they recognized that gender differences in Computing classes exist they appeared to be mostly gender-neutral when they refereed to their interactions with their students and their expectations. Their expressed gendered beliefs about boys and girls in the Computing class were not exclusively in favor of boys while most of the CTs seemed to be gender sensitive when they referred to general gender differences in CS and their role as CTs.

P3: Gender Neutral Interaction Initiation – Favoring Boys on the Whole. The CTs fall into P3 expressed mainly constraining beliefs regarding themselves as CTs and a mix of constraining and empowering concerning CS as a school subject. Mostly, they expressed gendered beliefs in favor of boys expecting more from them and mentioning gender differences in Computing classes by highlighting boys' advanced skills and engagement in the learning process. Their *gendered beliefs in favor of boys* were also revealed when they described differently boys' and girls' interests and preferences in CS, assigned diverse characteristics to boys and girls, mentioned different ways of learning CS and characterized differently boys and girls in relation to CS. Finally, the CTs in P3 appear to be *gender insensitive* to gender differences in CS, disregarding the significance of their role in the preservation and the mitigation of the gender disparity in CS.

P4: Overall in favor of boys. Most P4-CTs expressed mostly *empowering beliefs regarding themselves* as CTs and *a mix of empowering and constraining belief* about *CS* as a *school subject* and its teaching and learning. Even though they expressed a few gender-neutral views regarding their interactions with their students, they mostly expressed *gendered beliefs favoring boys* as they have more expectations from them, believe that they perform better than girls, they are really interested in CS and their main characteristic in relation to CS is their strong cognitive skills. Finally, it seems that they expressed a *mix of gender sensitive and insensitive beliefs* referring to gender differences in CS and the role of a CT as they acknowledged the gender gap in CS but they underestimated it as a problem, admitting that in some cases they had not considered gender issues before and also that they had not helped to close the gender gap.

P5: Overall in favor of girls. P5-CTs are empowered by their intrinsic motives to become CTs and their expectation to become better and more efficient teachers. Most of them feel confident with their teaching skills and expressed empowering beliefs regarding CS as a school subject and the role of a CT. P5-CTs seem to be gender-neutral regarding their interaction and expectations from their students. However, they expressed gendered beliefs concerning gender differences in Computing classes but these beliefs were not exclusively in favor of boys or girls. Finally, it seems that P5-CTs were aware of the gender gap in CS, acknowledged the severity of the problem and were gender-sensitive in their lesson planning recognizing the importance of their role.

7.3.3.2 Synergies between the interactions of Computing Teachers' beliefs and their actual teaching practices

P1: Gender Neutral. *P1-CTs* expressed a mix of empowering/constraining, gender-neutral/gendered, and gender-sensitive/gender-insensitive beliefs. Some of their expressed beliefs have been reflected in their actual teaching practices, while others seem to be suppressed by others different and maybe weightier beliefs. Specifically, P1-CTs' confidence in their teaching skills and the expressed *gender-neutral* beliefs, concerning their interactions with girls/boys and their expectations from them, were reflected in their actual practices as they interacted with girls/boys equally, provided the same kind of feedback to their students and gave them adequate time to answer to their questions. On contrary, their stated empowering beliefs about CS as school subject, the facilitating role of the CT and the needed student competences have not been fully reflected in their practices. Even though they provided mainly positive feedback to girls/boys, they interacted with them mainly through low level questioning. The lack of confidence in their CS skills may have constrained them or several real-life and contextual factors such as students behaviors, time, resources, course contents might have had an impact on the degree of belief-practice consistency. Likewise, the gendered beliefs expressed by some of the P1-CTs in favor of boys, concerning their better performance compared to girls, have not been mirrored in their practices. Finally, P1-CTs' expressed gender-insensitive beliefs also reveal that they are not fully aware of the gender gap in CS and their role in bringing it.

P2: Gender Neutral Interaction Initiation – Favoring Girls on the Whole. P2-CTs expressed several constraining/empowering, gender-neutral/gendered, and gender-sensitive beliefs. Most of them were reflected in their actual teaching practices. Despite their extrinsic motivation and, in some cases, the lack of self-expectations, they feel really confident with their teaching skills and expressed empowering beliefs regarding CS as a school subject and its teaching and learning. These beliefs are actually reflected in their practices by employing a mix of low and high level questions in their interactions with students, providing several kind of feedback to them, and giving them enough time to think and answer their questions. The gender-neutral initiation of the interactions from P2-CTs can be attributed to some gender-neutral beliefs they expressed, regarding their expectations from girls/boys and the acknowledgement of both girls' and boys' positive characteristics. P2-CTs' gendered beliefs were clearly reflected in their actual practices. Specifically, in class, P2-CTs empowered girls by employing high level questions enhancing their logical and analytical skills, praised and enabled them more frequently than boys boosting their self-esteem, and interacted with girls by being mostly close to them. Finally, all of them seem to be aware of the gender gap in Computing and they recognize they critical role.

P3: Gender Neutral Interaction Initiation – Favoring Boys on the Whole. It seems that the three male P3-CTs expressed mainly constraining beliefs regarding themselves as CTs, a mix of constraining and empowering concerning CS as a school subject, mainly gendered beliefs in favor of boys and gender insensitive beliefs regarding gender differences in CS. The coexistence of gendered, constraining, and gender-insensitive beliefs seems to be mirrored in their actual teaching practices. Their gendered beliefs in favor of boys were clearly reflected in their practices, as, despite the fact that they addressed question to girls/boys equally (or the whole class), they empowered mainly boys addressing to them high level questions, providing positive-enabling feedback, and they were close to them during their interactions. Particularly, P3-CTs' reported belief that boys are really capable, confident, interested and engaged in CS in combination with their view that the needed competence for a student to succeed is interest and ability, along with their expectations from boys could justify their gendered practices. This gendered attitude may also be attributed to their expressed constraining beliefs and their insensitivity towards gender differences in CS. In fact, their extrinsic motives and the lack of self-expectations as well as the belief that CS as a school subject is mainly programming and computer use may deterred those CTs not only from employing activities that would stimulate all of their students but providing enabling feedback in order to support and engage both girls and boys in CS too. Moreover, their belief that gender gap in CS is not an actual problem that has to be faced and their acceptance that they had not considered gender issues before, either regarding their lesson planning or the significance of their role in bridging the gender gap, could explain their gendered practices in class. The coexistence of these constraining, gendered and gender-insensitive beliefs in P3-CTs' minds may serve as an alarming indicative that they will continue to embrace the same gendered practices in the future, therefore, it will not be that easy to act towards the bridging of the gender gap in CS.

P4: Overall in favor of boys. P4-CTs expressed a mix of empowering/constraining, gender-neutral/gendered, and gender-sensitive/gender-insensitive beliefs. However, their actual practices in class divulged that their gendered and gender-insensitive beliefs appeared to play a central role and those were the ones reflected mainly in their real practices. The coexistence of a mix of inconsistent beliefs in P4-CTs' minds guided those teachers to act in favor of boys in class, addressing more questions to boys, interacting with them through a mix of low and high level questions, encouraging and reinforcing mainly them by providing appropriate feedback. Their constraining belief regarding the practical aspect of CS as a school subject and their belief that the required competences for a student is high cognitive skills and interest, along with their gendered beliefs that boys perform better, have the needed abilities and are expected to succeed in CS, prevailed and therefore guided P4-CTs' practices. Their empowering, gender-neutral and gender-sensitive beliefs seemed to be supressed and are not fully reflected in their actual practices. Specifically, their intrinsic motivation and their expectancy to become efficient teachers, their empowering belief that CTs should enable and support all of their students; their expressed gender-neutral expectations from their students along with their statement of gender-neutral interaction, and their expressed gender-sensitive belief that gender differences exist as well as they had not reinforced consciously gender gap in CS, were not fully mirrored in their actual practices. Nevertheless, some of these beliefs appear to be prevalent in their non-verbal behavior as they provided girls and boys sufficient time to provide an answer to their questions, and in most cases, their moves in the lab/classroom also indicated a neutral attitude.

P5: Overall in favor of girls. P5-CTs expressed mainly empowering beliefs regarding themselves as teachers, a mix of constraining and empowering beliefs concerning CS as a school subject, gender-neutral and gendered beliefs regarding girls/boys in relation to CS as well as gender differences in a Computing class, and gender-sensitive beliefs concerning gender differences in CS and their role in bridging the gender gap. It seems that most of their expressed beliefs were mirrored in their teaching practices. Their reported empowering beliefs about themselves, their gender-sensitivity and awareness of the gender gap in CS as well as the acknowledgment that girls need further support and guidance to succeed in CS courses, since they feel insecure, seem to be those central beliefs that play a key role which influence their practice. In class, P5-CTs attempted to empower, enable, support and encourage girls by enhancing their self-esteem, challenging them to think and develop higher cognitive skills. On the contrary, P5-CTs' expressed beliefs which were not mirrored in their practices, like gender-neutrality regarding the initiation of interaction and expectation from students, may not have been strongly held or real-life factors, such as students' behaviors, time, and course content, and other several contextual factors may have prevented teachers from embracing their beliefs in actual practice.

Section D. Discussion and Conclusions

Chapter 8

Discussion, Conclusions, Implications and Future Research Dimensions

Summary: This final chapter tries to reconcile all the issues researched and discussed in the present thesis, in an attempt to drain the essence of what has been studied and analyzed within the context of this work. It draws conclusions by offering a review of the main findings along with their interpretations and implications, presents the limitations encountered in the *Studies* and finally suggests areas for further research.

Gender issues in Computing and STEM disciplines have been a hotly debated issue in the research agenda of many researchers around the globe for more than three decades. Especially, the gender gap in the Computing education and the workforce has motivated excessive research in the field during the last decades. This work sought to provide useful insights in gender issues in Greek Computing education and offer valuable information that could be exploited by researchers and educators in the field by investigating the gender gap in Greek Computing education, challenging the myth about gender differences in cognitive skills and academic abilities in Computing as well as examining Computing teachers' gendered classroom practices, uncovering interrelationship with their gender-related beliefs.

In that sense, the aim of the present thesis was mainly threefold: (a) to investigate systematically the gender representation in Greek Computing education, (b) to study gender differences in preferences and performance in Computing courses, and (c) to examine Computing teachers' gender-related beliefs and practices by exploring what teachers say and what they do in class. Each of the aims of this thesis was further analyzed into sub-aims and appropriate research questions were posed. In order to fulfill this threefold aim and answer the research questions, three case studies were designed, *Study1*, *Study2*, and *Study3*, each approaching one of the aims of this thesis (see chapter 4). The main research findings and the conclusions drawn from these three studies are presented in the next section.

8.1 Review and Interpretation of Main Findings

8.1.1 Gender Representation in Computing and STEM Education in Greece

Study1 focused on the investigation of gender representation in Greek Secondary and Tertiary C+STEM education during the decade 2003-12. To draw the full picture, this study examined systematically: (a) teacher gender representation in C+STEM secondary education, (b) student (freshmen, graduates, master's degree graduates and PhD's) gender representation in C+STEM tertiary education, and (c) faculty member gender representation in C+STEM tertiary education. A quantitative study was conducted taking into account appropriate data that emerged from the Hellenic Statistical Authority for the decade 2003-12.

8.1.1.1 Teacher gender representation in Computing Greek Secondary Education. From the analysis of the data several conclusions were drawn. First of all, even though female teachers in secondary education are more than males, in Computing, it is the other way round as male Computing teachers are more than their female counterparts every year of the decade. Women constitute almost 46% of the population of the Computing teachers in Junior High School and almost 38% in High School. It seems, therefore, that under-representation of women in Computing profession is not confined to the various competing professional areas related to Computing, but it is also true in the teaching field. In addition to the above, in spite of the fact that females are underrepresented in both Junior High School and High School, the difference in percentages in these two levels appear to be quite different. It is evident that female Computing teachers tend to be appointed in Junior High Schools. This issue could be explained mainly due to the nature of the Computing courses offered. In Junior High Schools, Computing courses are more general, whereas in High School those are more specialized. Finally, female teachers are better represented in *'Computing'*, compared to the rest STEM disciplines in secondary education. As has become obvious from the data analysis, *'Math'* is the most male-dominated field in comparison with *'Phys'* and *'Eng'*.

To conclude, it seems that female teachers are less prevalent than males in Computing and STEM GSE; yet female teachers were better represented in *'Computing'* compared to the rest STEM disciplines. The lack of female teachers in C+STEM secondary education, who could act as mentors/role models is a non–encouraging factor, mainly because they could influence female students on selecting these discipline in their University studies and future career. In fact, female Computing teachers are even fewer in Lyceum (General and Vocational), 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. This issue could be connected to the low participation of females in *'Computing'* depts, especially freshmen, which is discussed next.

8.1.1.2 Student/graduate gender representation in Computing Greek Tertiary Education. The results arising from the analysis of the data regarding the student representation in Computing GTE can be viewed as both alarming and encouraging in terms of female freshmen's, graduates', master's degree graduates' and PhD graduates' participation. It is a fact that in *'Computing'*, every year of the decade, females were less prevalent than males at all levels of University study. Especially the female representation in freshmen in *'Computing'* depts can be viewed as a cause for concern, since, not only female freshmen were less prevalent than males every single year of the decade but their percentages followed an 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 Greek Universities. It is also alarming that the percentages of female freshmen in *'Computing'* depts are lower than in any other STEM discipline. These findings are in line with relevant research in other countries (eg. Camp, 2012; Gürer & Camp, 2002). Regarding the female graduates' representation in Computing undergraduate studies, even though their percentages were, for most of the decade, the lowest of all the STEM disciplines, the upward trend is an encouraging mark. Apart from '*Bio/Env'* depts in which females were more than males, the low female representation in *'Phys'*, *'Math'* and *'Eng'* depts is a worrying factor as well. The female representation in master's degree programs and PhDs in *'Computing'* depts was also the lowest among all STEM disciplines. Nonetheless, the upward trend in the percentages of female graduates of master's degree programs in *'Computing'* depts over the last seven years of the decade is another promising point. It verifies that a considerable percentage of women pursue and achieve a Computing master's degree after graduation. Likewise, despite the low percentages, as the decade progressed, there was an noteworthy increase in female graduates of PhDs in *'Computing'* depts.

To conclude, the results of this study suggest that females are less prevalent than males at all levels of study in Computing GTE and their percentages are the lowest among STEM disciplines at all levels of study. Nevertheless, unlike previous research findings, the *'pipeline shrinkage problem'* would appear to have no effect on Computing studies in Greece. In addition, it seems that there was no dropout from level (undergraduate studies) to level (master's degree studies) in Greek *'Computing'*, *'Phys'* and *'Eng'* depts 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 C+STEM education. This serves to indicate that there is a clear need to attract and convince women to enter the C+STEM education fields. More precisely, 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.

8.1.1.3 Faculty gender representation in Computing GTE. The data analysis indicates that females are underrepresented in faculty members, in every rank, in C+STEM depts, apart for *'Bio/Env'*. This situation could be also characterized as alarming in *'Computing'* and *'Eng'* depts, due to the discouragingly low percentages of females. Numbers of female faculty members in *'Computing'* seem to be even worse, as their percentages - in every rank - were the lowest among the STEM disciplines for almost all the years in the decade under study. It is should be noted that during the whole decade, there were two Computing depts that had no female faculty members whatsoever. The findings regarding the female representation by ranks merit attention as well. It is interesting that in *'Computing'* and in each of the remaining STEM fields, among the different ranks of faculty members, females were best represented in the position of lecturers, then assistant professors, associate professors and professors. Hence, it seems that the higher ranks of faculty members are dominated by males and the low percentages of females in these ranks equate to a low number of female faculty members. In particular, in *'Computing'*, even though professors constitute the majority of faculty members in these fields, the percentage of female professors was the lowest among all the ranks. On the other hand, females were best represented in the position of lecturers, who constitute the fewest faculty members in the aforementioned disciplines. This means that those females, who enter Academia in C+STEM, are clearly outnumbered by males in the higher ranks and in the total number of faculty members and have a tendency to occupy the lower ranks, probably indicating that females evolve slowly to the higher ranks.

To conclude, females are less prevalent than males in all ranks of faculty members in Computing GTE and their percentages, in every rank, were the lowest among STEM disciplines. In addition, females in Computing were better represented in the position of lecturer, while higher ranks of faculty members were dominated by males. The lack of female mentors/role models in C+STEM GTE is clearly a non–encouraging factor in influencing female university students to pursue an academic career in CS and STEM, one which would appear to develop into a vicious cycle, where females are not sufficiently involved in Academia and their absence affects future female participation in the field. Since *'Computing'* seems to have the worst female representation among all STEM disciplines, action needs to be taken so as to broaden their participation.

8.1.2 Student Gender and Course Preferences and Performance in Computing

Study2 focused on the investigation of gender differences in terms of student preferences and performance in CS undergraduate courses comprising the entire curriculum of a CS dept. A single case study was performed exploiting the records from a CS dept in Greece and data from 89 graduate degrees earned by CS students were quantitatively analyzed.

8.1.2.1 Student Preferences. The data analysis revealed some statistical significant differences in *preferences* between male and female CS graduates. In fact, a higher percentage of males compared to females preferred courses related to *software and hardware engineering*, whereas a higher percentage of females than males preferred courses related to the study of *theoretical CS* issues as well as courses related to the *social and human aspects of CS*. Despite the fact that female preferences in social sciences and humanities have already been supported by other researchers in relation to STEM education, female preferences both in theoretical CS courses and in social sciences and humanities – at the Tertiary level of CS education – have not yet been reported in the literature. Nevertheless, it is worth mentioning that gender differences in terms of preferences in CS courses included in the CS dept in question concern only a small number of courses (10 out of 75 elective courses). Yet, there is a large number of electives (31 out of 75 electives) which were chosen by less than 25% of both female and male graduates.

The aforementioned differences in gender preference regarding the courses of a CS dept probably reflect: (a) some stereotypical views of engineering as a masculine field, (b) previous experience in the field; for example, females entered university having less previous experience in programming than males (Beyer & Haller, 2006), and thus they avoid taking lab-based programming courses, (c) diverse personality characteristics (Beyer, 2014), (d) females' low self-efficacy beliefs in CS (Beyer, 2014), despite their having successfully managed to pass the demanding national exams to enter a Greek-CS dept, and (e) diverse values and interests, as males prefer mathematical and engineering subjects unlike females who prefer subjects oriented towards helping others and interacting with people (Beyer & Haller, 2006).

8.1.2.2 Student Performance. In terms of *performance*, it seems that there are no significant differences between the mean grades of males and females in most of the CS courses. Any statistically significant differences in performance were present only in a few CS courses (10 out of 100 courses) in favor of males (7 courses) and females (3 courses). In this sense, striking differences in performance in CS, as in other STEM fields (Alkhadrawi, 2015; Ding, Song, & Richardson, 2006; Kıran & Sungur, 2012), are not observed, indicating that the myth about actual gender differences in cognitive skill and academic ability is not based on real data

To conclude, the analysis of the data divulged that male students prefer, more than females, engineering and advanced CS courses compared to females, while females prefer courses related to theoretical issues in CS as well as courses related to the social and human aspects of CS. This study also revealed that there are not major differences in performance between males and females and that when different domains are taken into consideration, males tend to perform better at math and programming than females, and females better in courses related to interfaces between people and computers than males.

8.1.3 Computing Teachers' Gender-related Beliefs and Practices

Study3 placed emphasis upon the investigation of CTs' beliefs about themselves as teachers, Computing as a school subject, girls/boys in relation to CS, gender issues in a Computing class, gender differences in CS as well as the examination of their actual teaching practices in class in terms of their interactions with boys girls. Ultimately, possible associations between CTs' beliefs and their actual teaching practices in class were investigated to uncover synergies between the interaction of CTs beliefs and practices. To successfully fulfill the aims of the present study, interviews with 20 CTs were conducted in order to elicit their beliefs and observations in their Computing classes were made so as to examine their various instructional behaviors toward girls and boys from a gender-sensitive viewpoint.

8.1.3.1 Computing Teachers' gender-related beliefs. The CTs participated in the study expressed various: (a) constraining and empowering beliefs about themselves as teachers as well as Computing as a school subject and its teaching and learning; (b) gender-neutral and gendered beliefs about girls/boys in relation to CS as well as gender issues in a Computing class; and (c) gender-sensitive and gender-insensitive beliefs about gender differences in CS and CT's role.

Most of CTs appear to be constrained by their extrinsic motives to become CTs, they have no further expectation as teachers and feel weak regarding their CS skills. They focus on the practical aspect of the CS subject, suggesting a more traditional role for the CT, and they emphasize on the diligence and the exclusive interest and personal engagement in CS beyond school time as the only competences needed for success in Computing courses. Only a few are empowered by their intrinsic motives, their expectations to become better and more efficient teachers and their confidence in their teaching abilities emphasizing on various teaching strategies based on modern learning theories. The majority of the CTs expressed some gendered beliefs in favor of boys and almost all of them acknowledged different aspects of gender differences in Computing classes. There are also those who expressed gender-neutral beliefs regarding boys' and girls' interests and preferences in CS, their way of learning and their characteristics regarding CS, while most of them claimed that they interact equally with girls and boys having the same expectations of them. Finally, all of them seem to be aware of the gender differences in CS but most of them revealed a gender-insensitive profile as they do not see it as an actual problem and they had not considered any gender issues before in their teaching planning.

In terms of CT gender, most of the male CTs seem to be constrained by their extrinsic motives, the lack of self-expectations and their expressed weakness in their teaching capabilities. They emphasize on the practical aspect of CS subject by supporting that interest and experience beyond school time are the only needed capabilities for a student to succeed in CS. Nevertheless, some of them seem to be empowered by their confidence in their CS skills, expressing and supporting that CS could act as a mental tool, and simultaneously suggest that the CTs need to implement modern teaching strategies. Most of them expressed gendered beliefs in favor of boys in relation to CS and highlighted those aspects of gender differences in Computing classes that favor boys. However, some of them reported gender-neutral beliefs by stating that they try to interact equally with boys and girls and have the same expectations of all of their students. Finally, most of the male CTs, even though they are aware of the existence of gender differences in Computing, they mainly show a gender-insensitive profile by saying that gender differences in Computing is not a problem, revealing that in some cases they may have encouraged gender inequalities in Computing and they admit that not only they had not considered gender issues during teaching before but they are not willing to change this too.

On the contrary, most of the female CTs seem to be empowered by their intrinsic motivation, their expectation to become better teachers and their confidence in their teaching abilities. They underline that Computing as a subject has both theoretical foundations and practical dimensions and that CT's role should be to guide, support and assist students in learning by employing group work activities. Nonetheless, some of them seem to be constrained by their lack of confidence in CS and highlight diligence as the needed competence for success in a Computing course. Moreover, most of the female CTs expressed gender-neutral beliefs stating that mainly, there are not different domain preferences within the CS field between boys and girls, they acknowledged that girls need both support and guidance, and they attributed to them some strong personality traits. Eventually, as opposed to males, female CTs showed up mostly a gender-sensitive profile by advocating that the gender gap in CS is a real problem that should be overcome and they also understand their role in diminishing the gender gap as they admitted that in some cases they had tried to dispel gender stereotypes taking into consideration gender issues while teaching.

To conclude, the majority of the CTs expressed: (a) a mix of empowering and constraining beliefs regarding themselves as teachers and CS as a school subject as well as its teaching and learning, (b) a mix of gender-neutral and gendered beliefs regarding their students and CS as well as gender issues in Computing classes, and (c) a mix of gender-sensitive and gender-insensitive beliefs. In terms of teacher gender, even though there is not a clear pattern, it seems that male CTs expressed mostly: (a) constraining beliefs regarding themselves as teachers and a mix of empowering and constraining beliefs concerning CS as a school subject and its teaching and learning, (b) gendered beliefs favoring boys in relation to CS as well as several gender issues in Computing classes, and (c) gender-insensitive beliefs concerning general gender differences in CS. Regarding female CTs, they expressed mostly: (a) empowering beliefs regarding themselves as teachers and a mix of empowering and constraining beliefs concerning CS as a school subject and its teaching and learning, (b) gender-neutral regarding their students in relation to CS and recognized several aspects of gender differences in CS not favoring clearly students of one gender over the other, (c) gender-sensitive beliefs about general gender differences in CS and CTs' role in bridging the gender gap.

8.1.3.2 Computing Teachers' practices. Computing teachers' practices were studied in terms of CT-student interactions within the context of the four major axes of analysis: (a) frequency of CT-students interactions, (b) level of questioning girl/boys, (c) the kind of feedback provided both to the girls/boys, and (d) CTs' non-verbal behavior which was further analyzed with reference to wait time and physical position.

Most of the CTs were *gender-neutral* regarding the initiation of interaction with their students. Nevertheless, a considerable number of them interacted overall more with the boys, unlike a few CTs who interacted more with the girls because boys/girls answered more questions addressed to the class or they initiated more interactions with the CT. Interestingly, most of the CTs differentiated their questions as to their intellectual level because of the student gender. Nevertheless, there is not a clear pattern in favor of girls or boys, as half of them addressed a mix of low and high level question to the girls and low level questions to the boys while the rest half vice versa. Most of the CTs were *gender-neutral* as they provided the same kind of feedback to their students regardless of their gender. However, on closer inspection, it seems that CTs did *differentiate* the positive feedback provided to their students, favoring boys in some cases or supporting girls more often compared to boys. All of them provided the necessary time both to the girls and boys to get more thoughtful response, while most of them did not differentiate their physical position in class while interacting with their students.

In terms of CT gender, it seems that there are some clear patterns. Half of the *male CTs* interacted overall more frequently with the boys addressing questions to them more often compared to the girls. Interestingly, most of them interacted with the girls, employing low level questions but when they interacted with the boys they attempted to empower them to reach to higher levels of reasoning skills, using both low and high level questions. It is also clear that most of the male CTs were more supportive to boys compared to girls, praising and reinforcing them, while at the same time, in most cases, they avoided to provide the girls with any kind of feedback. Finally, most of the male CTs maintained the same attitude towards girls/boys and only a few chose to be mainly away from girls and closer to boys in an attempt to support and encourage them, making them feel more important.

On the other hand, it seems that *female CTs*-students interactions did not follow a clear pattern as some of the female CTs were gender-neutral; some interacted more frequently with boys and others more with girls. Nevertheless, most of the female CTs selected to interact with boys either by criticizing their behavior in class or engaging low level questions -while on the contrary- they empowered girls by employing high level questions advancing their logical and analytical skills. A remarkable number of female CTs provided positive feedback to girls, supported them, attempted to enhance their self-esteem and challenged them to think. At the same time, in most cases, female CTs were not so supportive to boys as they criticized their behavior or avoided to give them any kind of feedback. Finally, most of the female CTs did not differentiate their physical position in the lab because of the student gender, yet quite a few of them were mainly close to girls, maybe in an effort to support, guide and encourage them more than boys.

To conclude, the data analysis revealed that CTs' gender-related practices in terms of teacher-student interaction can be categorized into five main teaching profiles. There are those CTs who are *gender neutral* overall, as they initiate interactions with girls/boys equally or with the whole class, they address mainly the same type of questions to the girls/boys, provide the same feedback, and do not differentiate their physical position in class when interacting with their students. (*P1-gender neutral).* Moreover, there are those CTs who, even though they are gender neutral regarding the initiation of interaction, they differentiate the type of interactions, the given feedback and the physical position in class favoring on *the whole*) the girls (*P2-gender neutral interaction initiation-favoring girls on the whole)* or the boys (*P3-gender neutral interaction initiation-favoring boys.* Finally, there are those CTs who clearly favor the boys (*P4-Overall in favor of boys)* or the girls (*P5-Overall in favor of girls)* as they initiate more interactions with the girls/boys and differentiate the level of questioning, the feedback they provide and their non-verbal behavior. Interestingly, for this study, in terms of CT gender, half of the *male* CTs fall into P3 or P4, which indicates that they favored boys over girls, while most of the *female* CTs belong to P2 or P5, favoring girls on the whole. This apparent different behavior to boys/girls from male/female CTs is maybe guided not only by their different beliefs about girls/boys in relation to CS and/or other gender issues in the context of CS as a school subject, but also their general views about gender differences in CS.

8.1.3.3 Computing Teachers actual practices compared to their expressed beliefs. The study of the interrelationships between CTs practices and beliefs revealed that some of their expressed beliefs have been reflected in their actual teaching practices, while others seem to be suppressed by other different and maybe weightier beliefs. This finding is in line with relevant studies in the STEM fields which support that teachers' beliefs can influence classroom practices (e.g Calderhead, 1996; Fang, 1996; Kagan, 1992; Mansour, 2013; Pajares, 1992; Thompson, 1992). However, there is a set of research indicating that teacher practices is not always consistent with their beliefs (e.g. Calderhead, 1996; Ertmer, 2001; Fang, 1996; Mansour, 2013; Philipp, 2007). This fact can be attributed to the complexity of the belief system, as some of the teachers’ beliefs may be overpowered by others more central beliefs and are not reflected in practice (e.g Ajzen, 2002; Mansour, 2013; Nespor, 1987; Pajares, 1992). The inconsistencies between teachers’ beliefs and practices are also attributed to several socio-cultural factors within practice which can cause conflict and prevent teachers from putting their beliefs into actual practice (Mansour, 2013). For this study, both the reflected and the suppressed CTs’ beliefs, along with their practices could reveal whether CTs in each of the teaching profiles may act towards mitigating the gender gap by engaging girls in Computing. On the basis of the above arguments, a mix of empowering/constraining, gender-neutral/gendered, and gender-sensitive/gender-insensitive beliefs expressed by most *P1-CTs*. Some of their gender-neutral beliefs were reflected in their practices as they interacted with the girls/boys equally and provided them the same kind of feedback. However, it appears that their constraining beliefs, or other contextual factors, suppressed their empowering belief about Computing as a school subject that were not reflected in their practice since they employed mainly low level questions with their interactions with girls/boys. Even though their practices seem to be gender-neutral, their expressed constraining and gendered beliefs in favor of boys -even if they were not reflected in class- along with their gender-insensitive beliefs about the gender gap in Computing, may act as a barrier in engaging girls in Computing. In essence, it seems that these 'gender-neutral' practices are not going to mitigate the identified gender gap in Computing and promote girls' recruitment and retainment in Computing.

P2-CTs expressed several constraining/empowering, gender-neutral/gendered, and gender-sensitive beliefs. Most of them were reflected in their practices. They employed both low and high level questions and provided enabling feedback to their students, in accordance with their empowering beliefs about Computing as a school subject. Their gender-neutral beliefs were mirrored in the gender-neutral initiation of interaction, while their gendered beliefs in favor of girls were clearly reflected in class as they addressed high-level questions to the girls giving them enabling feedback more frequently than boys. To this end, it seems that these practices are in line with their expressed gendered beliefs, that girls need more effort, help, support and guidance from their CTs. P2-CTs' practices in class and their expressed gender-sensitive beliefs imply that they are aware of the gender gap in CS as well as the important role of the CT and may act towards bridging the gap.

P3-CTs expressed mainly constraining beliefs about themselves, a mix of constraining and empowering beliefs about Computing as a school subject, mainly gendered beliefs in favor of the boys and gender insensitive beliefs concerning general gender differences in CS. The coexistence of gendered, constraining, and gender-insensitive beliefs seems to be mirrored in their actual teaching practices. They addressed mainly high level questions to boys, provided enabling feedback to them, and were close to them while interacting, supporting and empowering them. These gendered practices could be also attributed not only to their constraining beliefs about themselves and Computing, but also to their expressed gender-insensitive beliefs. The coexistence of these constraining, gendered and gender-insensitive beliefs in P3-CTs' minds may therefore serve as an alarming indicative that they will continue to embrace the same gendered practices in the future. As a result, it will be definitely hard for them to act towards bridging the gender gap in Computing.

P4-CTs expressed a mix of empowering/constraining, gender-neutral/gendered, and gender-sensitive/gender-insensitive beliefs. It seems though that their gendered and gender-insensitive beliefs prevailed as those beliefs were mainly mirrored in their practices, suppressing their empowering, gender-neutral and gender-sensitive beliefs that were not fully reflected in their practices accordingly. These prevailed beliefs guided P4-CTs to interact more often with boys by employing both low and high level questions and provide them with positive-enabling feedback in an attempt to encourage and reinforce them. Despite the fact that they expressed several empowering and gender-sensitive beliefs, their practices in class revealed that those beliefs are not central in their belief system to some extent or that there were other external factors that finally prevented their reflection in class. The coexistence of so many inconsistent beliefs in P4-CTs' minds and the predominance of those beliefs, which lead to gendered practices in favor of boys, indicate that these CTs' practices broaden the gap instead of mitigating it.

P5-CTs expressed mainly empowering beliefs regarding themselves as teachers, a mix of constraining/empowering beliefs concerning CS as a school subject, gender-neutral/gendered beliefs regarding students and gender issues in class, and gender-sensitive beliefs about gender differences in CS. Most of their expressed beliefs were actually reflected in their teaching practices. Their empowering beliefs, their gendered beliefs in favor of girls along with their gender-sensitivity seem to be central in their belief system, as in class P5-CTs tried to enable and support girls by challenging them to think and develop their higher cognitive skills. Although some of their expressed gender-neutral beliefs were not mirrored in their practices, it seems that those CTs are aware of the gender gap in Computing and they attempt consciously to bridge it by empowering, supporting and encouraging girls.

To conclude, the analysis of the interrelationship between CTs' beliefs and practices revealed that there are eventually those CTs who tend to: (a) maintain the gender gap; (b) broaden the gender gap; (c) bridge the gender gap. In particular, even though some of the CT hold gender-neutral beliefs and their practices are mostly gender-neutral (P1), in fact, they do not act towards closing the gender gap, instead they maintain it. Actually, they are not fully aware of the gender differences in Computing and the coexistence of inconsistent beliefs in their mind lead them to supposedly gender-neutral practices. On the other hand, there are those CTs who, despite the fact that they are gender-neutral regarding the initiation of interactions with girls/boys, their actual practices show that eventually they either favor girls (P2) or boys (P3). The gender-sensitive beliefs for P2-CTs and gendered beliefs in favor of boys for P3-CTs prevail and guide their actual practices in class. The former may act towards closing the gender gap, while the latter towards broadening it. Finally, there are those CTs whose gendered beliefs in favor of boys or girls are dominant and they are mainly reflected in their practices in class, favoring boys (P4) or girls (P5) respectively. Nevertheless, P4-CTs (who are male CTs for this study) seem to hold several inconsistent beliefs and these constraining, gendered and gender-insensitive beliefs suppress those empowering and gender-sensitive beliefs, which could lead to more gender-sensitive teaching practices. By contrast, for P5-CTs (mainly female CTs) their empowering, gendered in favor of girls and gender-sensitive beliefs prevail and they are mirrored in their practices as it seems that they consciously attempt to bridge the identified gender gap in Computing.

8.2 Implications of the Findings

Computing teachers, Computing faculty, Computing students, and researchers in the field can utilize the results of the *Studies* of this work so as not only to realize and be aware of the issues addressed but also try finding answers to the under-representation of females in Computing. In particular, the findings of *Study1* could be exploited by Computing teachers in order to realize the under-representation of females in the CT population and the lack of female students in Computing depts as well as perceive the importance of their role and the impact they may have on their students' choice of Computing as a field of education, especially in the case of females. In addition, taking into account that one of the crucial issues addressed in this study is the need for recruitment and not so much retention of women in Computing depts, researchers from Computing education -in collaboration with Computing teachers- could design appropriate teacher education programs which could possibly have a positive effect on the recruitment of women in Computing. What is more, female secondary school students could realize, from real-life examples (female students-role models in Computing depts who study successfully CS at undergraduate and graduate level), that they are able to pursue Computing studies successfully, not only at a undergraduate level but also at a master and/or a PhD level. Female students in Computing depts can also take advantage of the results of this study by overcoming the anxiety and dispelling the stereotypes that they will not succeed in their Computing studies, surely boosting their self-confidence in pursuing studies of higher level. Moreover, Computing faculty members can employ the results of *Study1* to realize and be aware of the relative lack of female faculty members in Computing depts and their under-representation in Computing compared to that in other STEM disciplines. Female faculty members in Computing depts, in collaboration with researchers, should take action to stimulate females to participate in the field, highlighting their work and their contribution, revealing in this way the need for diversity in the Computing field and especially the actual need for the presence of females in every field of Computing as well as in Academia. Hence, the results of this study may be crucial for Computing faculty members and researchers to consider how the situation may have been wrongly-handled in the recent past and to investigate the reasons for the female under-representation, trying to follow the example set by other STEM fields in order to engage females in Computing tertiary education.

The findings of *Study2* revealed the absence of significant differences in the performance of male and female graduates and challenged the 'myth' that there are actual gender differences in cognitive skills and academic ability in Computing. Thus, this study could be a contribution to the field of Computing teaching and learning as well as to Computing teacher education, so that, Computing teachers and students may be able to dispel such gender 'myths' and remove perceived boundaries within certain Computing career paths. This study also provides some useful insights into the males' and females' preferences in Computing, triggering an effort for the modification of the Computing curriculum and Computing instruction in order to adjust the content of Computing to the preferences and the interests of males and females as well. This study could also contribute to the field of Computing curriculum and instruction by determining the extent to which more effort is needed within the education system to design appropriate Computing curricula that meet females' interests. Subsequently, the present study could lead to the incorporation of appropriate teaching strategies which could challenge persistent myths about gender differences in Computing performance and perceived obstacles about gender and Computing.

Finally, the results emerged from *Study3* can be exploited by CTs, CT educators and researchers in the field in order for them to reflect on teacher's gender-related beliefs and practices to design appropriate teacher education programs and research experiments. In fact, CT educators can ask Computing teachers to elaborate on the teacher gender-related beliefs and practices emerging from this study, with a view to reflect on their relationships, consistencies and contradictions, challenging their adequacy and through self-reflection to become self-aware of their own gender-related beliefs and practices. Eventually, even CTs could reflect on their own practices in order to categorize themselves into one of the teaching profiles discovered and also be aware of other teachers' practices. Building on the above, CTs could adopt those aspects of teaching practices that enable and engage both girls and boys in Computing and challenge those constraining and gendered practices that act towards broadening the gender gap in the field. In addition, the '*Computing Teacher-Student Interactions Tool*', which was developed in the context of *Study3* in order to record and examine CT-student interactions, could be exploited from other researchers in the related fields to conduct any relevant experiments both with other teachers and in different educational contexts.

8.3 Limitations and Propositions for Further Research

8.3.1 Limitations

Although some of the results of this thesis are in line with the findings of other studies in C+STEM disciplines, this work is subject to several limitations. *Study1* concerns a certain decade as well as a particular population and a country with a specific secondary and tertiary education system. *Study2* also confines to a certain period of time and a particular CS dept in Greece with a certain curriculum and degree requirements. Likewise, *Study3* investigated Greek CTs' beliefs and practices that may be shaped by several social and contextual factors in the Greek educational system. Thus, any generalization of these results should be undertaken with caution and be limited to countries, populations and CS depts that have similar characteristics to those of the participants in these studies. Any research finding that differs from those of other studies should be handled with the same prudence. Another limitation has to do with the number of subjects participating in *Study3* (20 participants). More specifically, the sample is not perceived to be representative of the population nor generalizable. This limitation also applies in *Study2* in which the degrees of a limited number of graduates (89 graduates) were studied. Further empirical and longitudinal studies are needed to replicate the findings with larger populations and in different (international) educational contexts, which could lead to more accurate findings. Finally, since *Study3* was conducted by a single person, there is evidently the risk of subjective bias.

8.3.2 Propositions for Further Research

This thesis yields interesting research prospects. Firstly, the lack of female Computing teachers in secondary education, highlighted in *Study1,* only one step before students make their University choices and consequently their career path, is an issue over which there appears an urgent need for serious concern. The actual impact, especially on female students, ought to be examined through qualitative studies, investigating students' thoughts on the deficiency of female mentors and role models in Computing secondary education. Moreover, the under-representation of female students in Computing tertiary education, especially regarding freshmen, is another topic that triggers further research. Studies exploring further the social and contextual factors, which affect females' participation in Computing studies, would reveal possible obstacles for females that could be finally overcome. In addition, studies about both male and female Computing students' beliefs in reference with the needed abilities and skills as well as their views on gendered issues in Computing could possibly uncover dynamics within the Computing disciplines. What is more, the inadequate presence of women in Computing Academia, as described in *Study1*, with the consequent lack of gender diversity in the field as well as the lack of female Computing mentors and role models in tertiary education appear to be a reason to worry and an issue that is worth investigating. Hence, it is of the essence to explore the roots of this under-representation in the field, unmasking the reasons why female Computing university students do not pursue an academic career, identifying the obstacles that female faculty members in CS depts face on their way to recognition, progression and retention in the field of Computing Academia. The example set by *'Bio/Env'*, and even by other STEM disciplines such as *'Phys'* or *'Math'*, in which female representation is clearly better, can be also followed in Computing, challenging more females to participate. Lastly, further similar longitudinal studies in different time periods in Greece and across several countries need to be conducted in order to be compared with the findings of *Study1*.

Additionally, even though *Study2* provided useful insights into males and females performance and preferences in Computing, the conclusions drawn need to be verified by conducting other similar studies with larger sample size and in different countries. What is more, a further investigation of student preferences in CS, this time through qualitative studies, may reveal other factors which can have an impact on their course choices. Eventually, appropriate educational programs could be designed, implemented and evaluated in order to render every aspect of Computing interesting, appealing and fascinating both for males and females in Secondary and Tertiary education.

Lastly, the research about CTs' gender-related beliefs and practices could be developed even further, taking into consideration the limitations of the present work. Thus, similar studies with Computing teachers across several countries would ensure the validity and the generalization of the findings of *Study3*. Nevertheless, CTs' beliefs and practices, as highlighted in this study, can be taken into account in the design of appropriate Computing teacher education programs in which teachers' gender-related beliefs and practices will be 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 females' strengths and essential characteristics. There is a wealth of literature on the field of the transformation of teachers' beliefs and practices, and it would be interesting to investigate the role of diverse factors in changing teachers' gender-related beliefs and practices, such as teacher self-reflection in their beliefs and practices, teacher participation in small communities of practice or provision of vicarious experiences.

On the whole, it is hoped that this work has provided both useful and new insight into: (a) the representation of both genders in Computing education in Greece, in terms of teachers in secondary education, students in undergraduate and graduate Computing studies and faculty members in Computing depts, (b) gender differences in performance and preferences in Computing, and (c) CTs' gender-related beliefs, their actual practices and associations among them. It is also hoped that the results, derived from the *Studies* in the context of this thesis, would be utilized from CTs, CTs educators, Computing students, Computing faculty and researchers to eliminate the obstacles that cause the gender gap in Computing, bring to an end the vicious cycle that has developed in the field and finally make some critical changes to reverse the situation. Grace Hopper once said: "*Humans are allergic to change. They love to say, 'It's always been done that way'"*. Yet, the challenge is posed, are we able to make this change?

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