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Involving Girls in STEM: A Study on Gender Bias from Schooling to University

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Abstract

Gender disparity in STEM fields, particularly in computer science (CS), remains a global challenge due to the underrepresentation of women. Factors such as educational background and pre-university choices could influence this disparity. Gender bias and stereotypes, starting in childhood, could significantly deter female enrollment in CS programs. This study explores the educational experiences and reasons behind gender disparities in the Bachelor's degree program in Computer Science at the University of Padova, aiming to promote gender equality in academia and the Information and Communication Technology industry. Data were collected from 167 students, revealing gender differences in secondary education and motivations for pursuing CS. Gender disparities were noted in perceived difficulties in facing different courses, from programming to numerical calculus, and in perceptions of bias, with females more likely to perceive women as disadvantaged, and the stereotype of "CS is for men" being more prevalent among older generations. Both genders expressed moderate optimism about increasing female representation in CS and suggested solutions such as school interventions, practical initiatives, curriculum integration, scholarships, and female quotas.

Keywords: gender bias, gender gap, social bias, women in computer science, university education

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Gender equality is a critical topic attracting global attention among the Sustainable Development Goals (SDGs) of the United Nations to be achieved by 2030 (United Nations, 2023). Among other goals, SDG 5 specifically aims to ensure women's* full and equal participation in all areas of life, including education and employment. In the context of science, technology, engineering, and mathematics (STEM), this means addressing the barriers and biases that hinder girls' and women's participation in STEM education by creating opportunities for them to pursue and excel in STEM careers. Women workers' percentages in the STEM field fluctuate around 26% of the total workforce in the United States (U.S. Department of Labor, Women's Bureau, 2024) and 35% in Europe (European Institute for Gender Equality, 2023). This evident gender gap widens even further if we consider the specific area of computer science (CS) or information and communication technologies (ICT), where the percentages of women are unbalanced at 24% in the United States (U.S. Department of Labor, Women's Bureau, 2024) and 17% in Europe (European Institute for Gender Equality, 2023). Moreover, these numbers are decreasing over the years (Martinez & Christnacht, 2021).

Gender disparity in STEM is not solely a social concern; it also has crucial economic implications. In Italy, while the employment rate for STEM graduates is 88.5%, the highest among professions, women are still underrepresented, with only 1.7% working in ICT compared to 8.2% of men's occupations (Agenzia Nazionale Stampa Associata, 2023; Italian National Institute of Statistics, 2022). As the demand for STEM workers continues to grow, especially in CS, achieving gender equality in this field could yield significant economic benefits. Europe is facing a shortage of two million STEM professionals, and this deficit continues to expand. As the need for highly qualified professionals in these disciplines intensifies, the European Union is strengthening its initiatives to tackle this urgent issue through the implementation of its new STEM Education Strategic Plan (EU STEM Coalition, 2025).

Gender bias and inequalities in STEM and digital fields persist from early education, creating barriers that discourage girls from pursuing studies and careers in CS and ICT (McGuire et al., 2020; Stone, 2019). These biases are deeply rooted in school environments and contribute significantly to the underrepresentation of women in

* In this manuscript, the terms "men/boys" and "women/girls" are used interchangeably with "male" and "female," consistent with common academic practice. We acknowledge the important distinction between gender as a social construct and biological sex. For clarity, our study considers the sample population as cisgender, meaning participants whose gender identity corresponds with the sex assigned at birth. Therefore, for simplicity and consistency, we primarily use "male students" and "female students" or "men" and "women" when referring to our participants.

these sectors across Europe (European Parliament, 2020). Therefore, this paper examines the educational choices influencing students to pursue CS degrees. Conducted with the Department of Mathematics "Tullio Levi-Civita" at the University of Padova, an Italian university, the study analyzes students' backgrounds and perspectives to identify factors contributing to the underrepresentation of women in the CS and ICT workforce.

Gender Disparity in STEM University Education

The Gender Equality Strategy 2020–2025 emphasizes the imperative to address the gender disparity among STEM graduates, particularly in academia, where vertical segregation exists, accentuated by the ongoing digital transformation of the European Union's economy (Directorate-General for Research and Innovation, 2021). Within STEM disciplines, the proportion of European women with bachelor's and master's degrees stands at 32% and 35%, respectively. Women account for just one in three STEM graduates and only one in five ICT specialists in the European Union (European Commission, 2025). This underrepresentation persists across all academic rankings within STEM, with 35% of PhD students, 28% of researchers, and 19% of senior researchers being women (Directorate-General for Research and Innovation, 2021; Fatourou et al., 2019).

Regarding the University of Padova, which is involved in this study, only 22% of students enrolled in STEM courses are female. The 2022–2024 Gender Equality Plan of the University reports that only 9.5% of newly matriculated students in ICT courses and 10% of those already enrolled in 2020–21 were females (University of Padova, 2019). Among the 149 students enrolled in the Bachelor's degree course in CS in the 2020–21 academic year, only 14 were women.

Gender Bias in CS: Theoretical Framework

The theoretical model of Master and Meltzoff (2020), the STEreotypes, Motivation, and Outcomes (STEMO) developmental model, integrates recent findings from social and developmental psychology to explain the gender gap in STEM. This framework underscores the significant influence of social factors, including stereotypes and self-representations related to a sense of belonging, in contributing to gender disparities in STEM interests and academic achievements (Master & Meltzoff, 2020).

One key factor in particular emerges as influencing the gender gap formation: the collective stereotypical image of who a computer scientist is and what this person does for work (Cheryan et al., 2013; Clayton et al., 2009). A recent study demonstrated that students from the first to the twelfth year of school of various ethnic groups and cultures held the stereotype, both for personal interest and for ability, that IT is a discipline "for boys" (Master et al., 2021). In other studies, when children were asked to “draw a computer scientist,” representations of the typical male nerd with glasses bent over a computer emerged (McGuire et al., 2020; Nardelli & Corradini, 2019). The researchers further noted that the sense of belonging (or lack thereof) to the CS discipline significantly influences females’ dedication to curricular choices and extracurricular activities related to CS, with the opposite effect for males (Master et al., 2021).

Despite evidence that genders have equal cognitive abilities at birth (Kanaki & Kalogiannakis, 2022), stereotypes linking males to superior technical skills persist due to influences from parents, teachers, and peers. Judgments and stereotypes from the educational and parental environment are not only expressed verbally but also manifest through the shaping of experiences that lead to gender segregation starting from early childhood (Boe & Woods, 2018). As an example, Davis and Hines (2020) conducted a meta-analysis focused on toy preferences, highlighting how toys serve as part of a child’s environment influencing their cognitive development (Bovet, 1976). This early environmental shaping through gender-typed play can contribute to the formation and reinforcement of gender stereotypes that later influence academic and career choices. The binary view of school subjects as “for males” or “for females” is often reinforced by teachers (de Wit et al., 2021; McGuire et al., 2020; Stone, 2019; Sun et al., 2018; Vekiri, 2013). Moreover, gender bias among math teachers negatively affects students’ math scores and enrollment in advanced studies (Lavy & Sand, 2018). Consequently, these stereotypes shape educational choices, creating a domino effect reinforced by intrinsic and extrinsic motivations.

In Italy, about 78.67% of male secondary students attend technical institutes, where IT is taught equally with other subjects (Ministero dell’Istruzione dell’Università e della Ricerca, 2022). Conversely, girls are less likely to enroll in these institutes due to beliefs that they are “only for boys” or that girls lack the necessary skills to succeed (Deiglmayr et al., 2019; Screpanti et al., 2018). Instead, many girls interested in science opt for scientific secondary schools, where 40.64% of students are female, compared to 17.48% in technical institutes (Ministero dell’Istruzione dell’Università e della Ricerca, 2022). Nevertheless, CS integration in Italian secondary schools is often lacking or optional, contributing to the gender gap at the university level.

These pre-university factors play a critical role in shaping students’ future academic confidence, motivation, and career choices in CS and related STEM fields. Early exposure to CS concepts and hands-on experience have been shown to enhance students’ self-efficacy and interest, which are key predictors of persistence in STEM disciplines (Chen et al, 2024; Malik et al., 2025). Additionally, social cognitive career theory (Lent et al., 1994) posits that career development results from a dynamic interplay of personal, behavioral, and environmental factors, including prior learning experiences and contextual supports or barriers, such as gender stereotypes and educational opportunities (Pantic et al., 2018). Previous studies further suggest that gendered socialization during secondary schooling contributes to self-selection, where females and males may gravitate towards different fields due to perceived gender-role congruence and societal expectations (Goreth & Vollmer, 2023). As few girls enter technical institutes or have basic CS knowledge, even fewer pursue CS or STEM degrees. This disparity is strengthened by the perception of CS as a male-dominated field and insufficient exposure to the subject in primary and secondary education (Pantic et al., 2018). Understanding pre-university influences is also important for designing interventions that can enhance motivation and foster equitable participation in CS courses from an early age.

Previous data showed that even if some girls overcome stereotypes and choose to enroll in CS education, they may face problems (Leaper & Starr, 2019). They feel disadvantaged in preparation compared to their male peers (Kallia & Sentance, 2018), although recent university data demonstrate that girls graduate with higher scores than males (University of Padova, 2019). Recent studies have also highlighted that CS women feel undervalued or overlooked or face sexist comments and harassment from their peers and professors, which often leads female students to express emotional discomfort and a sense of powerlessness (Fietta et al., 2023; Leaper & Starr, 2019).

The biases mentioned so far influence not only school and university choices as well as girls' performance perception but also the work path in the IT field for women like a self-perpetuating circle (Yates & Plagnol, 2022).

The Present Study

Considering the association between schooling choices and gender stereotypes, this study aims to investigate gender differences related to educational paths and experiences among female and male students enrolled in the Bachelor's degree program in CS at a major European university. Regarding previous educational paths and gender-stereotype perception, the research questions we have investigated are as follows:

1. **Research Question 1 (RQ1)**. What differences exist in the educational paths of male and female CS students before enrolling in a CS Bachelor's degree program, particularly in relation to the type of pre-university education they received (e.g., technical institutes vs. other educational backgrounds)? This question investigates both the influence of gender stereotypes and the role of social identity and self-selection on early educational choices, core aspects of the STEMO model, which emphasizes how early stereotypes and social identity shape self-representations and motivation in STEM fields starting from childhood and adolescence.
2. **Research Question 2 (RQ2)**. How do male and female CS students perceive gender stereotypes within the field of CS? This question aligns with the "stereotypes" construct in STEMO theory. According to the model, these stereotypes impact self-identification, sense of belonging, and perceived ability, thus influencing academic pathways and persistence.

Regarding enrolling in a CS Bachelor's degree program and attitudes towards courses, we investigated the following research questions:

3. **Research Question 3 (RQ3)**. Do gender differences in educational background, reasons for enrolling, and gender stereotypes influence the perceived level of preparedness when enrolling in a CS Bachelor's degree program? The motivation to enroll and the perceived preparedness correspond to the "motivation" and "outcomes" dimensions of the STEMO model. These outcomes are shaped through the internalization of stereotypes and mediated by constructs such as self-efficacy, academic self-concept, and belonging.
4. **Research Question 4 (RQ4)**. What are the differences in attitudes towards CS courses between male and female students during their Bachelor's degree studies (e.g., which courses are perceived as the most challenging with particular focused attention to programming)? This question directly addresses the "outcomes" dimension of STEMO, focusing on subjective experiences, difficulties, and academic self-perceptions like task value and expectations for success.

We also extended the research by studying the perception that the gender gap in CS could be narrowed in the future and to identify potential future initiatives in that direction.

5. **Research Question 5 (RQ5)**. Can the gender gap be narrowed? How can we do it? How do male and female CS students agree with initiatives to promote gender equality in CS? This question engages with motivational and outcome expectations for the future, addressing the final elements of STEMO theory, highlighting how interventions targeting stereotypes, growth mindset, and belonging can increase motivation and improve outcomes, and how student beliefs about equity initiatives reflect their engagement with these change mechanisms.

Method

In this section, we report how data exclusions, sample size, manipulations, and measures in the study were consistently determined with reporting standards for quantitative research (Appelbaum et al., 2018). All research materials are available by emailing the corresponding author. Data analysis was conducted using JASP and R software (JASP Team, 2020; R Core Team, 2020). This study's design and its analysis were not pre-registered.

Research Procedure and Data Collection

This study is structured as exploratory and primarily quantitative, with a questionnaire developed based on preliminary qualitative interviews. First, we studied the literature and developed the hypotheses reported above; based on these, we interviewed the subjects and extracted key themes from their responses. This initial qualitative phase involved interviews with 27 CS students (14 males and 13 females), whose insights helped confirm key themes and identify new ones related to gender disparities and biases. These themes informed the construction of the questionnaire through a bottom-up approach: We translated and drafted questionnaire items to quantitatively measure these topics. The final step was the review: The draft questionnaire was reviewed by two of the authors with expertise in CS and psychology, respectively, for clarity, content relevance, and phrasing. The draft questionnaire was also subsequently reviewed by the same initial small group of students to ensure the questions were interpreted as intended, using the "think-aloud" method during the questionnaire revision.

This approach actively involves participants, whose perspectives enrich the research and enable a deeper exploration of gender issues. Moreover, our study emphasizes amplifying female students' voices, addressing the underrepresented experiences of women in CS programs (García-Holgado et al., 2021). By focusing on their opinions, we highlight critical aspects of gender representation and suggest potential initiatives. A brief report of interview outcomes and the final questionnaire version are reported in Supplementary Information* available online. (Table S1 presents the origin of different initiatives).

The questionnaire consisted of six sections:

1. Demographic information: We asked participants about their age, gender, and current university career status.

2. Gender differences in secondary school education (RQ1): Participants were asked about their schooling path (e.g., secondary school typology, gender composition of their class during secondary school, and whether they had studied CS during secondary school).

3. Gender differences in perceiving gender stereotypes (RQ2): Participants were asked to express their perception and belief that women are disadvantaged in CS, and were asked how common the bias is among young and old communities that "CS is a man's thing." The questions and answer scales were:

- "*Do you think girls/women are disadvantaged in CS*?" with answers on a Likert scale ranging from 1 (*no, not at all*) to 5 (*yes, absolutely*);
- "*In your opinion, is the idea 'CS is for men' present among young people/adults (15–40 years old)*?" with answers ranging from 1 (*no, not at all*) to 5 (*yes, very much*);
- "*In your opinion, is the idea 'CS is for men' present among adults/elderly (+40 years old)*?" with answers ranging from 1 (*no, not at all*) to 5 (*yes, very much*).

* Supplementary Information are available in the repository associated to this publication https://doi.org/10.5281/zenodo.18187015

4. Gender differences at the time of CS university course enrollment (RQ3): Participants responded to questions about various personal aspects at the moment of enrolling in this type of bachelor's degree program (e.g., reasons why they were enrolling in CS, and how prepared they felt compared to their colleagues, particularly in programming skills). The questions and answer scales were:

- "*When you enrolled, how prepared did you feel compared to your classmates*?" with answers ranging from 1 (*not at all*) to 5 (*very much*);
- "*When you enrolled, how prepared were you in programming*?" with answers ranging from 1 (*I knew nothing*) to 5 (*I knew everything; the first year was a review of what I already knew*);
- "*Which first-year course scared you the most*?"

5. Gender differences during CS university courses (RQ4): We asked participants who had already graduated in CS to report which was the most challenging course of their bachelor's degree.

6. Future of women in CS (RQ5): In the final section of the questionnaire, participants expressed their views about the future number of women in CS, with answer on a Likert scale from 0 (*there will be fewer women than today*) to 4 (*there will be more women than today, even more than men*). Participants also expressed their agreement on how to reach an equal gender distribution in the IT field, from 1 (*totally disagree*) to 5 (*totally agree*), about different initiative options like educational intervention for families and schools against cultural bias or the introduction of the CS discipline before university choice with both male and female students/CS professors involved, or the creation of female scholarships to access the CS faculty. The complete questionnaire is available in the Supplementary Information.

The questionnaire was distributed among CS students at the University of Padova in October 2022. Students currently or previously enrolled in the CS Bachelor's degree program were invited to voluntarily participate in this research. The study was advertised during university classes and disseminated on social media, such as Instagram and Telegram. The inclusion criteria to participate in the study were (a) being of legal age and (b) having previously studied or currently studying CS at the University of Padova. All participants were required to provide informed consent before starting the questionnaire. The questionnaire was completed online on the Google Form platform and lasted approximately 15 minutes.

Protection of Vulnerable Populations

IRB approval was obtained for this study, with the research procedure designed in accordance with the Declaration of Helsinki and approved by the Ethics Committee for Psychological Research at the University of Padova. Participants were free to skip any survey questions or demographic details they found too sensitive. Particular care was taken to anonymize sensitive interview data, omitting identifying details to protect confidentiality. While the study explored personal information related to gender minorities, we avoided presenting data in ways that could risk identifying vulnerable participants.

Participants

A total of 168 participants took part in the quantitative study. The sample consisted of students who had completed or were completing the three-year Bachelor's degree program in CS at the University of Padova. Thirty-seven (22.02%) were females, 130 (77.38%) were males, and one student (0.60%) was non-binary. The non-binary participant was excluded from the data analysis. Recognizing that genders are not limited to the binary categories of "man" and "woman" is crucial; therefore, these gender identity issues deserve further investigation with an ad hoc structured study.

The average age of the final 167 participants was 23.41 years (*SD* = 3.17, *range* 18–37 years). The year of enrollment in the bachelor's degree program varied from 2010 to 2021 (*M* = 2018, *SD* = 2.43). At the time of administration of the questionnaire, participants were distributed in the academic path as reported in Table 1.

Concerning the sample size, a post hoc power analysis was computed using G*Power. A sample size of 167 was sufficiently large to achieve statistical power ($1\text{-}\beta$) = 0.85 in a t-test involving two groups with independent means, given a significance level $\alpha = 0.05$ and a medium effect size (0.50; Faul et al., 2007).

Statistical Methodologies

The study used a t-test on independent samples to assess significant differences between genders in continuous variables, with Cohen's d reported for effect size (Cohen, 1988). For non-normally distributed variables, the Mann-Whitney test was employed, with

Table 1. Distribution of Participants by Academic Level

Sample distribution in the academic path	%
First year of Bachelor's Degree	0.60
Second year of Bachelor's Degree	2.99
Third year of Bachelor's Degree	41.92
Out of the three prescribed years of Bachelor's Degree	12.57
Dropped out of their Bachelor's Degree path	0.60
Bachelor's Degree graduated	11.38
First year of Master's Degree	11.38
Second year of Master's Degree	8.38
Out of the two prescribed years of Master's Degree	2.99
Master's Degree graduated	4.79
PhD student	2.40

rank-biserial correlation (*r*) as a non-parametric measure (Field et al., 2012; King & Eckersley, 2019). Chi-square tests (χ^2) were used for categorical variables, and Fisher's Exact Test was applied when sample sizes were small (Field et al., 2012). Odds ratios (*OR*) were reported for binary variables, and standardized residuals (*z*) for those with more than two levels. Bootstrapped multiple regression was conducted to analyze the relationship between educational path, stereotype perception, and female students' perceived preparation for enrolling in CS. The stepwise selection method and bootstrap confidence intervals were used to improve validity due to the small sample size, as recommended by Field et al. (2012). For all analyses, the *p*-value was set at .05.

Results

The following findings highlight significant gender disparities starting with educational backgrounds, where female students are less represented in technical secondary schools and have lower prior exposure to CS compared to their male peers. Female students consistently perceive higher levels of gender bias and disadvantage in the CS field and express differing motivations and preparation levels when enrolling in CS programs. Challenges during university, such as the perception of difficulty in programming courses, are reported more frequently by women. Despite these obstacles, there is cautious optimism among all students about increased female representation in the future, though full gender parity remains elusive. The study also identifies promising initiatives, ranging from early educational interventions to scholarship programs aimed at correcting these disparities.

Gender Differences in Secondary School Education (RQ1)

The percentages and the number of participants for the diverse types of secondary schools are reported in Table 2. The analyses showed a significant difference between males and females for the secondary school of origin. The Chi-square test (χ^2 = 12.01,

Table 2. Distribution of Males and Females Among the Types of Secondary Schools and the Relative Percentages

	Females (% of all females)	Males (% of all males)	Total sample (% in total sample)
Technical institute	**10 (27.03%)**	79 (60.77%)	87 (52.10%)
Scientific secondary school	22 (59.46%)	44 (33.85%)	66 (39.52%)
Other schools	5 (13.51%)	9 (6.92%)	14 (8.38%)
Total	37 (100%)	130 (100%)	167 (100%)

Note. Significant results are in bold.

$p < .01$, $z = -2.11$) indicates that the proportion of female students who attended a technical institute was significantly lower than male colleagues (complete results are reported in Table S2 in the Supplementary Information).

The gender composition of the classes of origin was also different between males and females. As stated in the Introduction, in the Italian context, there is a marked gender segregation in secondary school types, with technical institutes being predominantly male and linguistic or humanistic high schools predominantly female (Ministero dell'Istruzione dell'Università e della Ricerca, 2022). Indeed, females were significantly more frequently in female-dominated classes than males were ($\chi^2 = 13.59$, $p < .01$, $z = 2.92$), although overall, most participants came from predominantly male classes (see Table 3). No other statistical gender differences emerged (all *z* results are reported in Table S3 in the Supplementary Information).

Another interesting result is that 85.39% of males had already studied CS in secondary school, while the percentage dropped to 62.16% for female students. This difference is statistically significant ($\chi^2 = 9.80$, $p < .01$, $OR = 0.28$, *95% CI for OR* [0.12, 0.64]).

Gender Differences in Perceiving Gender Stereotypes (RQ2)

The results indicated that female students, on average, had a higher belief in the disadvantage faced by women in CS, with a mean response of 3.00 ($SD = 1.33$) on a 5-point Likert scale where 1 = "No, not at all (disadvantaged)" and 5 = "Yes, absolutely (disadvantaged)." In contrast, male students had an average response of 1.86 ($SD = 1.10$). Thus, women perceived a significantly greater level of disadvantage in the CS field compared to men ($t_{(165)} = -5.30$, $p < .01$, $d = 0.58$, *95% CI for Cohen's d* [−1.37, −0.61]).

Overall, CS students perceived this bias as more prevalent among the older population (> 40 years old; $M = 3.98$, $SD = 1.14$) compared to the younger population (15–40 years old; $M = 3.07$, $SD = 1.10$). This difference was statistically significant ($t_{(166)} = -12.36$, $p < .001$, $d = -0.96$, *95% CI for Cohen's d* [−1.14, −0.77]). When examining the perceptions of male and female students separately, female students showed a higher perception of

Table 3. Distribution of Females and Males Among the Types of Secondary School Classes and the Relative Percentages

	Females (% of all females)	Males (% of all males)	Total sample (% in total sample)
Mostly male class	21 (56.76%)	103 (79.23%)	124 (74.25%)
Gender balanced class	9 (24.32%)	23 (17.69%)	32 (19.16%)
Mostly female class	**7 (18.92%)**	4 (3.08%)	11 (6.90%)
Total	37 (100%)	130 (100%)	167 (100%)

Note. Significant results are in bold.

this stereotype (M = 4.38, SD = 0.95) compared to their male counterparts (M = 3.86, SD = 1.16) in the older population. This difference was statistically significant ($t_{(165)}$ = –2.48, p < .05, d = –0.46, *95% CI for Cohen's d* [–0.83, –0.09]).

Gender Differences at the Time of CS University Program Enrollment (RQ3)

Gender differences were observed regarding motivations driving enrollment (see Table 4). Consistent with the educational path, we found that many more males than females were motivated to enroll in the CS university program to continue studies in a discipline they studied in secondary school (24.32% of females vs. 46.15% of males). Moreover, males were significantly more motivated by a passion for video games (5.41% of females vs. 23.08% of males). Conversely, more females than expected enrolled in the CS university program motivated by curiosity to explore the CS discipline (40.54% of females vs. 14.62% of males).

In terms of how well prepared the participant felt compared to her/his classmates, the total sample showed an average response of 2.95 (SD = 1.17). Female students (M = 2.35, SD = 1.21) felt significantly less prepared than their male undergraduate classmates (M = 3.12, SD = 1.10), $t_{(165)}$ = 3.69, p <.001, d = 0.69, *95% CI for Cohen's d* [0.31, 1.06]. For the questionnaire item about perceived preparation in programming, the total sample obtained an average score of 2.96 (SD = 1.29). Again, a significant gender difference emerged ($t_{(165)}$ = 4.51, p <.001, d = 0.84, *95% CI for Cohen's d* [0.46, 1.22]), with female students (M = 2.16, SD = 1.24) feeling less prepared than males (M = 3.19, SD = 1.21) in programming, which is a core subject in CS.

Table 4. Distribution of Reasons for Enrolling in the Bachelor's Degree Program in Computer Science According to Gender

Reasons for enrollment	Females	Males	Total sample	Difference between genders
Continue with studies from secondary school	9	**60**	69	χ^2 = 5.66, p <.05, OR = 0.38, *95% CI for OR* [0.16, 0.86]
Curiosity	**15**	19	34	χ^2 = 11.94, p <.001, OR = 3.98, *95% CI for OR* [1.76, 9.02]
Passion for video games	2	**30**	32	*FET p* <.05, OR = 0.19, *95% CI for OR* [0.02, 0.82]

Note. The last column reports the statistics related to the significant difference between males and females. No significant gender differences for *passion for computers*, *passion for programming*, *advice from an acquaintance/friend/relative*, *have good job opportunities after graduation*, *have a future job compatible with starting a family*, and *other* reasons (complete results reported in Table S3 in Supplementary Information). Significant results are in bold.

At the time of enrollment, there were also gender differences concerning the most feared courses of the first year (see Table 5). Computer architecture (10.81% of females vs. 2.31% of males) and programming (62.16% of females vs. 17.69% of males) frightened female students significantly more than their male peers. Conversely, the mathematical analysis course (40.54% of females vs. 76.15% of males) scared boys more than girls. Overall, the most intimidating course (68.26% of all students) was mathematical analysis.

Influence of Education Path and Stereotype Perception on Perceived Preparation

We conducted multiple regression analyses to investigate the association of the educational path variables and gender stereotype perceptions previously analyzed with the level of perceived preparation at the moment of enrollment in the CS program among female students ($N = 37$).

Secondary school typologies, gender composition of the school classes, having studied CS, reasons for enrolling in the CS program, and gender bias perception variables (women disadvantaged, stereotypes among young and old population) were entered as independent variables in the multiple linear regression model. Following a stepwise variable selection method, four of them were included in the model, and significant regression results were found ($R^2 = 0.71$, *adjusted* $R^2 = 0.67$, $F\text{-}change_{(1, 32)} = 6.81$, $p < .05$). Specifically, a one-unit increase in passion for programming is associated with a 0.53-unit increase in self-perceived general preparation compared to peers, whereas a one-unit increase in the belief that people over 40 think CS is for men is associated with a 0.45-unit decrease in perceived preparation. A one-unit increase in the intention to continue studying a subject already pursued in secondary school is associated with a 0.33-unit increase in perceived preparation, while a one-unit increase in passion for computers is associated with a 0.25-unit decrease in perceived preparation, according to the standardized coefficients (see Table 6).

Table 5. Distribution of Participants Pursuing Bachelor's Degree Program in Computer Science in Relation to Educational Courses That Intimidated Them the Most When They Enrolled

First-year courses	Females	Males	Total	%	Difference between genders
Mathematical analysis	15	**99**	114	68.26	$\chi^2 = 16.86$, $p < .001$, *OR = 0.21, 95% CI for OR [0.10, 0.46]*
Computer architecture	**4**	3	7	4.19	*FET p* <.05, *OR* = 5.07, *95% CI for OR* [0.81, 36.28]
Programming	**23**	23	46	27.55	$\chi^2 = 28.54$, $p < .001$, *OR* = 7.64, *95% CI for OR* [3.43, 17.06]

Note. The last column reports the significant statistics related to the difference between males and females. No significant gender differences for *English*, *Logic*, *Operating systems*, *No courses*, and *Every course* answer option (complete results reported in Table S4 in Supplementary Information). Significant results are in bold.

Table 6. Multiple Linear Regression on Educational Path and Gender Bias Related to "General Preparation Compared to Colleagues" in Female Students

						95% CI		95% bca*CI	
	Unstandardized	S.E.	Standardized	t	p	Lower	Upper	Lower	Upper
(Intercept)	4.31	0.57		7.58	<.001	3.15	5.47	2.63	5.70
Passion for programming	**1.28**	0.23	**0.53**	**5.52**	**<.001**	0.81	1.75	0.77	1.74
CS is for men > 40 years old	**−0.57**	0.12	**−0.45**	**−4.72**	**<.001**	−0.82	−0.32	−0.84	−0.18
Continue with studies from secondary school	**0.91**	0.27	**0.33**	**3.44**	**<.01**	0.37	1.45	0.25	1.61
Passion for computers	**−0.62**	0.24	**−0.25**	**−2.61**	**<.05**	−1.10	−0.14	−1.07	−0.23

Note. RMSE = 0.69. ANOVA $F_{(4, 32)} = 19.40$, $p < .001$. The previous steps' statistics are reported in the Supplementary Information available online. CS = computer science; bca = bias-corrected and accelerated. *Bias correction accelerated with bootstrapping based on 5,000 replicates. Significant results are in bold.

Among the same independent variables, four were found to be associated with the level of perceived self-preparation in programming (R^2 = 0.78, *adjusted* R^2 = 0.74, *F-change*$_{(1, 31)}$ = 6.64, $p < .05$). In particular, enrolling based on a passion for programming and continuing with studies from secondary school were positively associated with perceived preparation in programming. Additionally, studying CS at the secondary school level was positively but not significantly associated with feeling prepared in programming. Rather, passion for computers as a reason for enrolling in CS and believing that women are disadvantaged in CS negatively contributed to the perceived level of preparation in programming (see Table 7).

Gender Differences in Perception of CS University Courses (RQ4)

In this section, we report only the results of male and female students who had completed a CS bachelor's degree (N = 69). They were asked which course was the most difficult among those they attended. There a statistically significant difference in the responses of males and females for one course: A higher percentage of female students than male students reported programming as the most difficult course (7 females vs. 7 males; χ^2 = 4.44, $p < .05$, *OR* = 3.58, *95% CI for OR* [1.05, 12.23]). Overall, 31.88% of graduates reported that the most challenging course of their academic career was software engineering, for which there were no significant differences between males and females (complete results reported in Table S6 in Supplementary Information).

Future of Women in CS: How Can the Gap Be Narrowed? (RQ5)

The closing section of the questionnaire asked students how many women in CS they expect in the future (in about 20 years). The average response score of the total sample was 2.22 (*SD* = 0.59). Grouping the sample by gender, males showed an average score of 2.18 (*SD* = 0.55), while females had an average score of 2.32 (*SD* = 0.71), around the answer "2 = *there will be more women than today, but always fewer than men*." This slight optimism did not significantly differ between males and females ($t_{(165)}$ = −1.25, p = 0.21, d = −0.238), as both believed more women will be involved in CS, but there will not be numerical gender parity.

Finally, students gave their opinions on viable solutions to increase the number of female students who enroll in the CS program. Gender differences only appeared for approving the creation of a scholarship or female quotas as incentives for obtaining CS degrees, with a higher female preference ($t_{(165)}$ = −2.58, $p < .05$, d = −0.48, *95% CI for Cohen's d* [−0.85, −0.11]). Considering the entire sample of male and female students, the three initiatives that received the most consensus were (a) interventions in middle schools before students choose secondary schools to make them more aware of CS, (b) interventions in secondary schools with practical campus initiatives/projects/competitions in the CS field, and (c) interventions in secondary schools with a greater integration of the CS discipline in all secondary school curricula. Complete results are shown in Table S7 in the Supplementary Information.

Table 7. Multiple Linear Regression on Educational Path and Gender Bias Related to "Preparation in Programming" in Female Students

						95% CI		95% bca*CI	
	Unstandardized	S.E.	Standardized	t	p	Lower	Upper	Lower	Upper
(Intercept)	2.01	0.34		5.96	<.001	1.32	2.70	1.40	2.64
CS in secondary school	0.49	0.25	0.20	1.94	=.06	−0.03	1.00	0.02	0.94
Passion for programming	**1.03**	0.21	**0.42**	**4.85**	**<.001**	0.60	1.46	0.62	1.49
Continue with studies from secondary school	**1.30**	0.27	**0.46**	**4.79**	**<.001**	0.75	1.86	0.65	1.88
Passion for computers	**−0.77**	0.23	**−0.31**	**−3.42**	**<.01**	−1.23	−0.31	−1.36	−0.37
Women are disadvantaged in CS	**−0.21**	0.08	**−0.22**	**−2.58**	**<.05**	−0.37	−0.04	−0.35	−0.03

Note. RMSE = 0.63. ANOVA $F_{(5, 31)} = 21.85$, $p < .001$. The previous steps' statistics are reported in the Supplementary Information. CS = computer science; bca = bias-corrected and accelerated. *Bias correction accelerated with bootstrapping based on 5,000 replicates. Significant results are in bold.

Discussion

Gender disparities persist at the academic level in STEM fields, reflecting longstanding social, cultural, and educational factors that continue to influence participation rates and experiences among different genders. According to recent theoretical frameworks, multiple societal factors and life choices specifically cause the small number of women in the CS field, such as gender stereotypes among children and adults, school history, and difficulties in university courses (Master & Meltzoff, 2020). Indeed, the observed gender imbalance (37 female students vs. 130 male students) in our sample likely reflects the existing gender disparity rather than solely being a consequence of sampling bias. This alignment with the actual population distribution underscores the validity of our findings and highlights the numerical gender disparities within the CS program at the University of Padova. As such, this imbalance is not a limitation but a key finding in itself.

This research provides additional empirical evidence of the influence of these educational and societal factors, especially regarding the diversity in the school histories of male and female CS students. In our sample, female students came predominantly from female classes, significantly more so than male students. Moreover, there was a lower presence of female students from technical institutes than expected. This is reflected in a significant difference between males and females who had studied CS in secondary school before enrolling in a university course: The number of female students was significantly lower. These results to RQ1 are in line with the Italian trend, which highlights a difference in males and females in pre-university schooling (Ministero dell'Istruzione dell'Università e della Ricerca, 2022; University of Padova, 2021) and preparation in the CS degree program (Falkner et al., 2015; Pantic et al., 2018).

The results of this study also provide empirical data on the prevailing gender stereotypes within the CS field. The perception that "CS is for men" was more prominent when referring to the older population, with female students having this perception more often than their male counterparts (RQ2). Importantly, since all survey respondents were young adults, these findings reflect their perceptions regarding other age groups rather than direct evidence from people of different ages. Nevertheless, the observation that the perception of bias was less pronounced among the younger population may be regarded as a favorable indication, implying that societal attitudes are evolving with the emergence of a new generation that places less significance on traditional gender stereotypes associated with CS.

Concerning RQ3, female students felt they lacked preparation at the beginning of their university careers, especially in programming, confirming the results previously found in the literature (Lehman et al., 2016). Moreover, programming courses scared females more than males. Conversely, males were more frightened when enrolling in university courses with more intensive mathematical applications. In addition, gender differences at the beginning of the degree partially persisted during the university path because female students, among those who completed the bachelor's degree studies, had more difficulty in programming. Therefore, we could state that the consequences of the distinct types of scholastic training were pervasive throughout the three-year university course (RQ4).

Differences in perceived competence during university enrollment are also related to varying motivations for enrolling in the CS Bachelor's degree program between males and females. A passion for video games and the will to continue their secondary school studies drove boys, while girls were moved by curiosity about the discipline. Indeed, this diversity of motivation (RQ3) is also a clear example of the lack of education in CS disciplines in Italian schools other than purely technical institutes (RQ1). In other words, this "curiosity" motivation may suggest a less confident or less developed initial interest in CS compared to male peers, which could stem from limited exposure to CS concepts in non-technical secondary schools, where many female students came from. Prior studies highlight that reduced opportunities during formative educational stages undermine girls' confidence and sense of belonging in CS fields (Perez-Felkner et al., 2025; Spieler et al., 2020).

Our findings thus reinforce the urgent need for earlier and more integrated CS education in secondary schools to foster genuine interest and build confidence among female students. By introducing CS concepts earlier and more broadly across different school types, educational systems can help mitigate gender disparities by broadening the pipeline and nurturing intrinsic motivation from a young age (Chen et al., 2024). This approach aligns with participant feedback advocating interventions targeting middle and secondary schools to improve awareness and engagement among girls prior to university enrollment.

Another interesting reflection that emerges from our results related to RQ3 concerns video games. As previously reported, toys are often gender-related from early childhood; however, video games could represent a more advanced form of play for adolescents. Therefore, once again, we observe a gender differentiation in previous experiences not only in the scholastic sphere but also within family and social environments, which can influence future high-level educational choices, such as university career. Previous studies indicate that video games exhibit significant gender differences. For instance, boys tend to prefer action, strategy, and competitive games, while girls more often select games that involve social interaction, communication, and narrative elements. These gendered gaming preferences, and also owning a gaming console, reflect broader social and cognitive patterns and can contribute to shaping skills and interests that affect high-level educational trajectories (Boyle & Connolly, 2009; Bustamante-Barreto et al., 2024). For example, Lavalle and collaborators (2025) found that women who play video games tend to feel more integrated into STEM programs and that there are notable gender differences in perspectives among male and female students. Another longitudinal study from the University of Surrey (Hosein, 2019) found that girls aged 13–14 who played video games more than nine hours a week were three times more likely to pursue degrees in STEM than non-gamers. On the other hand, a related study by Meza-Cuadra (2024) demonstrated that greater video game exposure during youth is correlated with increased likelihood of males obtaining bachelor's degrees in CS and related occupations, contributing to the widening gender gap in the field.

We have studied the impact of educational path variables and perception of gender stereotypes on the perceived level of preparation only among female students enrolling in CS courses. A passion for programming and continuity in CS studies were identified as positive factors, while beliefs associating CS with male dominance and a passion for computers were found to be negative factors. Again, these findings (RQ3) shed light on the importance of addressing stereotypes and encouraging diverse educational pathways to enhance female students' preparation and engagement in the CS field.

Finally, it emerged that the future of women in the CS field appeared positive; a higher percentage of women was expected in this sector (but not gender equality) within the next 20 years. This result confirms the future general perception of the perpetuation of the gender gap in CS for both females and males in the sample; contrasting results emerged about the decreasing presence of stereotypes (RQ2). Thus, in this last case, related to RQ5, we found no gender differences in perception of the future percentage of women in CS. Despite some progress, occupational horizontal gender segregation remains, with women entering traditionally male-dominated fields but often in subfields requiring social skills associated with women (Eagly et al., 2020).

To combat stereotypes, interventions should start early from middle to high school. Recent Italian legislation aims to enhance digital competencies, with a 2021 decree requiring educator training in CS for all educational levels during the 2022–23 academic year (Gazzetta Ufficiale della Repubblica Italiana, 2021). Starting in the 2025–26 academic year, there will be an emphasis on integrating coding into existing disciplines, highlighting the need for innovation at all levels.

In agreement with this, the most appreciated actions in our survey were interventions in middle and secondary schools to involve more girls in CS at the university level. To increase female representation in STEM and CS fields, it is essential to address bias in younger generations and train teachers to avoid reinforcing stereotypes that segregate disciplines by gender.

Many of the initiatives from our study are also reported in the literature as possible ways to increase the recruitment of female students in CS (Denner et al., 2015; Gretter et al., 2019), including the promotion of mentoring programs and summer camps for secondary school female students (Lyon & Green, 2020); the promotion of conferences and workshops on gender issues in CS and the creation of curricula that encourage gender balance (Faenza et al., 2021; Outlay et al., 2017; Weidler-Lewis et al., 2017); and the establishment of an EU Code Week, during which in 2019, nearly half of the participants (49%) were women and girls, representing a diverse cohort hailing from 80 countries (Directorate-General for Research and Innovation, 2021).

Moreover, recent initiatives involving gaming have shown promise not only in increasing the number of women pursuing STEM degrees but also in improving their academic outcomes (Lavalle et al., 2025). Although our study did not directly compare academic performance between genders, previous research suggests that females may attain significantly better learning performance than males following exposure to game-based learning environments (Tsai, 2017).

Finally, the only gender difference in the proposed initiatives was that female students showed more agreement on implementing pink quotas. However, while extrinsic motivations and incentives can attract students to CS, they are weaker than intrinsic motivations (Ryan & Deci, 2000). Cimpian et al. (2020) argue that such interventions benefit a small group of high-achieving women, failing to tackle deeper obstacles.

To promote gender equity and enhance STEM quality, we must recognize the fluctuating gender imbalance across achievement levels, often exacerbated by male-biased cultures that favor underperforming men over qualified women. Therefore, additional support, like pink quotas or grants, may be necessary to level the playing field where male privilege still exists.

Limitations and Directions for Future Research

This study has limitations, including a small sample size and gender imbalance, which may affect findings and interpretations of gender differences. Addressing these issues is crucial for accuracy and transparency. Future research should explore strategies to mitigate these limitations. Replicating the study with next year's students at the University of Padova will help assess the impact of initiatives from the CS program, leading to a better understanding of gender disparities in CS education. Additionally, this study is an exploratory, cross-sectional study intended to provide a "snapshot" of the perceptions, motivations, and pre-university backgrounds of students currently enrolled in the CS program. Therefore, the study could be replicated longitudinally in the future with the same student cohort in subsequent years to track changes over time, providing deeper insights into the evolution of motivational and academic outcomes.

This paper provides suggestions to address gender disparity in CS at the University of Padova. One author has used the research results to promote initiatives, including guidance for new CS students and events for secondary school students. Other initiatives include creating an online pre-course and offering tutoring for students struggling with programming and math.

Future initiatives at the University of Padova and beyond should focus on implementing proposed strategies to enhance gender equality in CS and monitor the psychological well-being of female students. Emphasizing the importance of mental health for both male and female students is crucial for their academic and professional success. Follow-up studies could gather feedback from first-year students to evaluate the effectiveness of initiatives aimed at achieving greater gender parity at the university. Additionally, replicating this research across diverse cultural contexts, including non-Western societies, could offer insights into global gender disparities in technology and CS education, contributing to more inclusive psychological research approaches worldwide. A limitation of this study is also the exclusion of participants with gender identities outside the cisgender male/female binary. Consequently, the findings do not reflect the experiences of non-binary or gender-diverse individuals. We acknowledge this constraint and highlight the importance of future research that includes all gender identities to better understand gender disparities in CS education.

Another limitation of our study is the absence of academic performance data. Future research should explore how motivational factors and pre-university experiences (e.g., gaming and videogaming, parental stereotypes) relate to actual academic achievement in CS courses. Finally, another limitation of this study is related to the use of a self-report instrument for data collection. The ad hoc nature of the questionnaire limits direct comparisons with other studies' findings. Future efforts should focus on developing standardized measures to address these limitations and advance research. These would enable systematic assessments of gender disparities and stereotypes in CS education across diverse university contexts and cultures.

Conclusions

The research provides crucial data for addressing the gender gap in CS and stereotypes limiting women's access to CS professions. It highlights the need for ICT education in Italian schools to combat gender stereotypes and increase female participation. Ongoing gender discrimination contributes to horizontal segregation at university levels, necessitating vigorous efforts to create a more inclusive environment. This work is part of the scientific research framework and initiatives aimed at (a) reporting actual gender disparities among STEM students' situations and (b) informing policies and practices to foster inclusivity in higher education STEM programs. Importantly, we recommend future longitudinal studies to track students over time, assessing the long-term effects of interventions and motivations on academic outcomes and gender equity. Indeed, interventions should promote diversity, inclusion, and gender equality, not only in our University but also by recognizing that the gender gap affects the entire world community. A shift in societal mentality is essential to challenge stereotypes and raise awareness of the barriers women face in this traditionally male-dominated field. As Karen Spärck Jones once stated, "*Computing is too important to be left to men*."

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Availability of data and material: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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