ISSN 2279-9362

# The Impact of the "Coding Girls" Program on High School Students' Educational Choices

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No. 689
January 2023

Carlo Alberto Notebooks

www.carloalberto.org/research/working-papers

# The Impact of the "Coding Girls" Program on High School Students' Educational Choices[1]

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January 2023

**Abstract**

This paper evaluates the impact of "Coding Girls", an educational enrichment program designed to address the underrepresentation of women and girls in the fields of science, technology, engineering, and math (STEM) in Italy by stimulating young female students' interest in programming and science and encouraging them to consider careers in STEM-related fields. Implemented in ten secondary schools in Turin (Italy) over the period 2019-2022, the Coding Girls program provided lab-based computer programming instruction as well as introductory talks on specific topics in STEM. The program was evaluated by randomized controlled trial.

Our results show that Coding Girls had a significant and positive impact on male and female students' programming skills and on their awareness of gender differences in the workforce. However, it did not seem to affect girls' aspirations to pursue higher education in STEM-related disciplines. The gender stereotypes children are exposed to from a very young age tend to steer girls and young women to the humanities. This bias is deeply entrenched and difficult to modify.

**JEL classification**: J16 I23

**Keywords**: Gender, STEM, Higher educational choice

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[1] The program was carried out in Turin (Italy) by Mondo Digitale and supported by Fondazione Compagnia di San Paolo. The program was evaluated by the authors within the Impact Evaluation Unit (IEU) at Collegio Carlo Alberto.

## 1. Introduction

Despite increasing numbers of women pursuing university and postgraduate education (e.g., master's and PhD programs, post-doctoral research), significant inequalities in male and female educational trajectories still have a major impact on their professional careers.

Recent research reports persisting and significant gender-related differences in higher educational choices. Women tend to gravitate toward the humanities rather than science, technology, engineering, and math (STEM). These studies have explored the impact of a variety of factors on this preference, including social and economic context, as well as family and school characteristics (for reviews, see Scantlebury and Baker, 2007 and Brotman and Moore, 2008).

Studies in Italy (e.g., Del Boca et al., 2011, and Castagnetti and Rosti, 2011) find that gender differences in employment and wages are significantly associated with educational choice. Although women make up over 60% of university graduates, only 36% of STEM majors are women. And despite the fact that women reach higher levels of education in a shorter period of time, the national employment rate for women (56.1%) lags far behind that of men (76.8%), according to 2021 data from ISTAT, the Italian National Institute of Statistics.

As indicated by recent data from the Alma Laurea consortium of Italian universities[2], male and female STEM graduates have an employment rate of 90% at five years from graduation, as opposed to only 75% in other fields. STEM graduates can expect to earn 1,642 euros per month on average, while those in other disciplines will take home 1,443 euros.

Coding Girls is an educational enrichment program aimed at encouraging young students to become more familiar with programming and at inspiring young female students to consider pursuing technological and scientific fields of study. The program was launched in 2014 under the auspices of the US Diplomatic Mission in Italy in conjunction with the Italian Ministry of Education, the Italian Ministry of Higher Education and Research, and Microsoft. In 2019, a three-year edition of the program was implemented in

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[2] https://www.almalaurea.it/sites/almalaurea.it/files/convegni/Bologna2022/sintesi_rapportoalmalaurea2022.pdf

Turin with the support of the philanthropic Fondazione Compagnia di San Paolo, and aimed at rigorously evaluating the program.

Gender-related occupational and wage gaps even early on in one's career depend in large part upon the university course chosen. Women tend to pursue fields in the humanities, whose graduates tend to have lower salaries and employment rates. It is therefore hoped that by encouraging female students to consider STEM majors, their career prospects in the fields of the sciences and engineering will improve, thus helping to reduce disparities in the labor market.

In the next section, we discuss recent literature focusing on disparities between the labor market outcomes of STEM and humanities graduates. We then describe the "Coding Girls" program and evaluation strategy in section three, and report the data and descriptive statistics in section four. We then move on to discuss the empirical results in section five before concluding with some policy considerations in section six.

## 2. Literature

One explanation for the gender disparities in the labor market outcomes of humanities and STEM graduates can be traced to gender stereotypes and the traditional division of labor in families. Students' degree choices are obviously shaped by cultural influences, and mirror the stereotypical division of gender roles in society.

Although women usually perform better at university than men, female students may experience greater challenges in the STEM field. A recent study (Jensen and Deemer 2019) defines the STEM fields, especially in engineering, as a "chilly climate" for female students: faculty expect less from female students, or lead women to believe that their ambitions are not as important as those of their male peers.

Several studies have shown that high school is a critical period for students' subsequent choice of what to study at university. While at high school, students develop a more realistic understanding of what their future careers might be, including gendered expectations about what work would be suitable, and self-assessment of career-relevant abilities (Legewie and DiPrete, 2012). Accordingly, by the 12th grade, girls are more likely to give up their goal of studying science, even if they expressed interest in the 8th grade, while boys are more likely to stick with it and to pursue a STEM pathway. Programs aiming to shape gender differences in STEM orientation and choices and to potentially influence students' preferences should thus take place during these critical years.

In Italy, where traditional gender norms continue to influence people's lives more than in other European countries, studies have shown that the challenges women face in pursuing STEM pathways often cause them to switch to a different degree program or to abandon their university studies altogether (Attanasio et al 2018).

Other studies on Italy note that that women are not actually underrepresented in all STEM disciplines. While their numbers are indeed lacking in technical subjects such as engineering and computer science, they are more numerous in biology and the health-care professions (Devita and Gianicola, 2017; Barone et al., 2019).

Another study mainly based on data from INVALSI tests, which are administered to students over the course of their school years shows that girls systematically score lower than boys, even after controlling for a set of individual and family background characteristics. Thus, girls' underperformance in math could explain the tendency for females to follow non-scientific careers (Contini et al., 2017).

Recent research has analyzed the sources of these differences. Using Alma Laurea data, Chise et al. (2021) find that one of the most significant factors is the occupational choices of parents. They observe sizable intergenerational associations in university graduation from STEM programs with parents' education. Priulla et al. (2021) analyzed data from MIUR (Ministry of University Research) and investigated the motivations of students' choices. They conclude that along with students' characteristics, also teacher information and guidance in high school is important. This result is confirmed by Barone and Assirelli (2020), who highlight the importance of the lack of information in high school about different paths of study. In this framework, the development and implementation of programs such as Coding Girls during high school could play a potentially significant role. These conclusions are confirmed by several studies discussed in the report "Cracking the code: Girls' and women's education in science, technology, engineering and mathematics", by UNESCO (2017). These studies agree that the gender gap in STEM fields does not depend on innate abilities or biological factors, but on the capacity of the brain to create new links; which is affected by experience, learning, and role models in youth (Bystydzienski et al. 2015; Master et al 2014). This underlines the potential importance of providing well-designed informational and educational campaigns in schools.

Our research contributes to this literature by exploring the impact of an educational enrichment program on girls' (and boys') skills and educational choices, on their awareness of gender stereotypes, and on their knowledge of the workforce.

## 3.The Program and its Evaluation

The Coding Girls program was conducted for three academic years (2019-2022) in 10 secondary schools in the Turin area. Three hundred students in their first, second, or third year of high school took part. The various modules of the program aimed at stimulating students' interest in computer programming and the sciences and at encouraging more girls to consider STEM as a potential degree and career. The overarching goal of the project was to reduce the gender gap in the IT sector, a still mainly male-dominated profession. The learning activities were distributed as follows: 75% computer lab activities, 15% role modeling and university orientation sessions, and 10% on specific topics concerning STEM and soft skills. Some activities were held online due to the pandemic.

The computer labs covered different topics and computer programs, providing basic instruction in computer programming according to the students' age and interests. For third-year high school students, an app-creation program called "App Inventor" was used to introduce students to the structure of the program, and to teach them programming fundamentals, application development, and debugging and customization procedures. The module for fourth-year classes, "Web Sites + Artificial Intelligence", introduced students to website creation using Wordpress - Altervista. Students learned how to design a website or blog, and then how to develop it, integrate it with artificial intelligence, and customize it[3].

Students also had the opportunity over the course of the program to meet and get to know role models from the university and business world, to be inspired by their stories, and to discover new areas of career interest. For example, STEM students from the University of Turin and the Polytechnic of Turin participated in the training sessions as role models, and several motivational videos of interviews with successful women in STEM careers were screened.

For evaluation purposes, each school provided at least one 11th and one 12th grade class willing to participate. Of these 28 classes, we randomly assigned the treatment, stratifying according to two criteria: whether there was at least one treated and at least one control class in each school. The composition of the sample is described in Table A1 (in the Appendix).

The treated classes took part in the program between December 2020 and March 2021. Interviews with both the treated and the control students were carried out in March 2021, when the treated classes were over but the control classes had not yet commenced. The

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[3] This information has been integrated with the report produced by the Compagnia di San Paolo available at the following link
https://www.compagniadisanpaolo.it/wp-content/uploads/CodingGirlsIIannualita.pdf

control classes attended the program between March 2021 and June 2021, when the course for the treated classes had finished and the data for evaluation had already been collected.[4]

The impact of the program was estimated through linear regressions, with robust standard errors at the school level:

$$y = \beta_0 + \beta_1 treated + \beta_2 X + \epsilon$$

where $y$ indicates various outcomes variables such as the ability to program, the intention to go to university and the expression of sentiments revealing gender bias regarding STEM.

We added two additional questions after the COVID outbreak to capture any positive or negative aspects of the lock-down. The first question sought to determine whether the provision of online courses had given students a greater appreciation of the use of information technology. The second instead aimed at finding out if students were aware of the potential negative impact of school closures on women's careers.

**4. Descriptive Statistics**

Table 1 shows the average values of the demographic characteristics of the male and female students in the sample. The information was collected during the first meeting of the program: in December 2020 for the treated students, and four months later (March 2021) for the control students. The members of our sample are male and female students between the ages of sixteen and seventeen. Most of them have at least one parent with tertiary education (46-49% of mothers and 39-46% of fathers). However, it is much likelier for the parents of female participants to have STEM fields or worked in the STEM sector than the parents of boys. Since most of the schools participating in the Coding Girls program were scientific secondary schools, the female participants would necessarily tend to have more "scientific" parents then the boys.

[4] The program was also implemented for students in their fifth year of high school. However, because of the heavy workload required before the final exam, fifth-year students participated in the program between December and March 2021, and were therefore not subject to randomization.

**Table 1**

Descriptive Statistics of the sample – Girls vs. Boys

| | Whole sample | | Significant difference |
|---|---|---|---|
| | Girls | Boys | |
| **Mean** | | | |
| Age | 16.69 | 16.73 | |
| **What is your mother's education level?** | | | |
| *Middle school diploma* | 0.13 | 0.14 | |
| *Superior middle license* | 0.40 | 0.36 | |
| *University or superior* | 0.46 | 0.49 | |
| **Did your mother study or work in the STEM field?** | 0.17 | 0.08 | **** |
| **What is your father's education level?** | | | |
| *Middle school diploma* | 0.24 | 0.20 | |
| *Superior middle license* | 0.35 | 0.34 | |
| *University or superior* | 0.39 | 0.46 | * |
| **Did your father study or work in the STEM field?** | 0.25 | 0.17 | *** |
| **Observations** | 289-316 | 166-189 | |

Notes: * p <0.20, ** p <0.10, *** p <0.05, **** p <0.01.

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Table 2 compares the average characteristics of the treated and control students, by gender. This balance is important for the identification of our effects of interest. We observe a very good balance of the demographic characteristics for both girls and boys.

**Table 2**

Descriptive Statistics of the Sample – Girls and Boys (Treated vs. Control)

| | Girls | | | Boys | | |
|---|---|---|---|---|---|---|
| | Treated | Control | Significant difference | Treated | Control | Significant difference |
| **Mean** | | | | | | |
| Age | 16.71 | 16.68 | | 16.62 | 16.79 | * |
| **What is your mother's level of education?** | | | | | | |
| *Middle school diploma* | 0.14 | 0.13 | | 0.16 | 0.13 | |
| *High school diploma* | 0.39 | 0.41 | | 0.33 | 0.38 | |
| *University diploma or above* | 0.46 | 0.45 | | 0.51 | 0.47 | |
| **Has your mother studied or worked in the STEM field?** | 0.16 | 0.19 | | 0.07 | 0.09 | |
| **What is your father's level of education?** | | | | | | |
| *Middle school diploma* | 0.23 | 0.25 | | 0.20 | 0.20 | |
| *High school diploma* | 0.39 | 0.31 | * | 0.33 | 0.34 | |
| *University diploma or above* | 0.37 | 0.43 | | 0.47 | 0.45 | |
| **Has your father studied or worked in the STEM field?** | 0.22 | 0.28 | | 0.20 | 0.15 | |
| **Number of observations** | 144-171 | 145-143 | | 58-82 | 108 | |

Notes: * p <0.20, ** p <0.10, *** p <0.05, **** p <0.01.

We now turn to programming ability. Table 3 reports the percentage of students who know different programming languages. This information was collected during the first meeting to assess students' skills before proceeding. The information is reported only for the treated. In fact, for the controls, the questions were asked four months later, and the students' skills could have changed in the meantime. The program most familiar to the majority of students was Scratch (71%), followed by Html (35%) and Algobuild (34%)[5]. The proportion of boys familiar with any of the programs was consistently higher than that of girls.

[5] All other information, collected through the pre-intervention interviews but not reported here, are available in the report by Basiglio (2021).

**Table 3**

Descriptive Statistics of the sample – Programming language (treated only)

| | Whole sample | Girls | Boys |
|---|---|---|---|
| Algobuild | 0.34 | 0.20 | 0.53 |
| Apache | 0.03 | 0.01 | 0.05 |
| Arduino | 0.11 | 0.10 | 0.14 |
| CSS | 0.04 | 0.03 | 0.05 |
| Html | 0.35 | 0.24 | 0.55 |
| Javascript | 0.19 | 0.21 | 0.16 |
| Pygame | 0.03 | 0.01 | 0.05 |
| Python | 0.06 | 0.01 | 0.14 |
| Scratch | 0.71 | 0.63 | 0.80 |
| Other programming languages | 0.59 | 0.53 | 0.67 |
| Observations | 112-146 | 66-74 | 42-61 |

Note: the number reports the proportion of students who have some knowledge of the program.

## 5. Evaluation of the Program Impact

We now discuss the empirical results of the evaluation of the program. The coefficients related to the impact of the program on several variables for both girls and boys can be seen in Table 4. The impact appears to be significant on several outcomes, although in some cases it is different for boys and girls

The program had a positive and significant impact on all of the students' self-perception of programming ability, increasing from 3.2 to 17.8% of girls perceiving themselves as very capable programmers and from 9.8 to 22.8% of boys.  For boys – and not girls - it also had a significant and positive impact on the intention to go to university (from 68.4 to 89%) an on a positive attitude to the STEM disciplines (from 22.5 to 44.1%). It also emerged that for girls only the program reduces the impact on the belief that women and men are paid the same in Europe and for both girls and boys instead increases the impact on the belief that women are paid 16% less than men.

**Table 4**. The impact of “Coding Girls”

| **Variable** [pre-treatment average, girls, boys] | Girls | Boys |
|---|---|---|
| | Treated b/se | Treated b/se |
| **Do you know how to program?** | | |
| *Yes (>=4)* | 0.146**** | 0.130*** |
| [0.032, 0.098] | 0.032 | 0.064 |
| **Do you think you will go to university?** | | |
| *Probably yes (>=4)* | -0.049 | 0.206**** |
| [0.880, 0.684] | 0.039 | 0.067 |
| **If so, do you think you’ll major in a STEM field?** | | |
| *Probably yes (>=4)* | -0.010 | 0.216**** |
| [0.172, 0.225] | 0.044 | 0.074 |
| **Are men more inclined to go into a STEM field?** | | |
| *Indifferent (>=3)* | -0.040 | -0.154** |
| [0.130, 0.316] | 0.050 | 0.079 |
| **Do you think that women in Europe earn** | | |
| *The same hourly pay as men* | -0.069*** | -0.054 |
| [0.101, 0.176] | 0.028 | 0.053 |
| *16% less than men;* | 0.062*** | 0.072* |
| [0.899, 0.803] | 0.029 | 0.055 |
| **Do you agree that “the pandemic might widen the gender gap?”** | | |
| *Partially (>=4)* | 0.037 | 0.123* |
| [0.272, 0.202] | 0.056 | 0.075 |
| **Observations** | 285-289 | 164-166 |
| **Specific questions for half of the 11th grade classes (dummy=1 if correct)** | | |
| Do you know what App Inventor is? | 0.272**** | 0.194**** |
| [0.678, 0.814] | 0.060 | 0.057 |
| What is the drag-and-drop system? | 0.239**** | 0.350**** |
| [0.525, 0.581] | 0.067 | 0.083 |
| What platform allows you to "market" and disseminate a mobile app? | 0.069 | 0.075 |
| [0.515, 0.442] | 0.075 | 0.103 |
| **Observations** | 184 | 105 |
| **Specific questions for half of the 12th grade classes (dummy=1 if correct)** | | |
| What is a CMS? | 0.173** | -0.008 |
| [0.579, 0.594] | 0.096 | 0.129 |
| What is usability and what does it mean to create a usable site? | 0.331**** | -0.021 |
| [0.439, 0.469] | 0.096 | 0.136 |
| What is the difference between a blog and a website? | -0.756**** | -0.650**** |
| [0.754, 0.703] | 0.068 | 0.077 |
| % treated | 3.46 | 0.60 |
| % control | 14.19 | 24.10 |
| % missing T | 46.37 | 34.34 |
| % missing C | 35.99 | 40.96 |
| **Observations** | 51-105 | 41-61 |

Notes: Regression performed with OLS (Ordinary Least Squares Method). Robust standard errors reported below the regression coefficient. * p <0.20, ** p <0.10, *** p <0.05, **** p <0.01.

* The number of observations for the question “If so, do you think you’ll major in a STEM field?” drops to 285 for girls and 162 for boys.

Finally, attendance of the Coding Girls program increased awareness of the potential risk that emergency measures related to the pandemic could widen the gender gap.

We also consider technical questions (with multiple choice options which imply a correct/incorrect answer rather than perceptions) to test whether participation in the program led to a measurable improvement in students' technical programming skills. The questions were different for students in the 11$^{th}$ and 12$^{th}$ grades, since the topics covered during the meetings were different. The questions included in the questionnaires were written by the trainers themselves. The bottom of Table 4 shows a positive impact on objective technical issues as well: for example, the percentage of 11th-grade girls familiar with "what the drag-and-drop system is" increased from 52.5 to 76.4% (+23.9 p.p.), and that of boys from 58.1 to 93.1% (+53 p.p.). The program positively enhanced all technical abilities apart from knowing the difference between a blog and web site. In fact, this was the most frequently skipped question, with only 5% of the treated students and 32% of the controls providing an answer. While 23% of the control students answered correctly that a website is a shop window and a blog is an online diary, the few treated students who even responded tended to give the same wrong answer that a web site is a container of articles and news and a blog is like an exhibitor of products and services. This may have been the result of a lack of a clear explanation during the labs, or perhaps the explanation given used words similar to those in the incorrect answer, leading students either to leave the question blank or to make the wrong choice.

Finally, it is interesting to observe differences in the data between girls and boys not participating in the program. First, a larger percentage of girls want to go to university than boys (88.0% of girls versus 68.4% of boys); second, boys are more likely to be oriented to STEM fields than girls (31.6% of boys versus 13.0% of girls); and a larger percentage of boys know "what App Inventor is" (81.4% of boys versus 67.8% of girls). Participation in program proves to even out these differences.

The larger percentage of girls willing to go to university - in absence of the program – may also explain the lack of effect of the program on the same variable and on the orientation toward STEM fields: girls are more mature, and may have already thought and decided about going to the university and what field they want to study. As previous research has found (e.g., Galasso et al, 2017), it is more difficult to influence decisions that have already been made.

## 6. Conclusions

The goal of the Coding Girls program was to stimulate girls' interest in computer programming and other STEM subjects in an attempt to reduce the gender gap in the workforce. Our results show that the program had several positive effects. First of all, it had a significant and positive impact on the programming skills of both girls and boys. In terms of the other outcomes considered, however, some gender-related differences emerge. While the program had a positive impact on boys' aspirations to pursue STEM studies at university, this was not true for girls. This can be related to gender stereotypes children are exposed to from a very young age which tend to increase girls' preferences for humanities and away from scientific fields. It could also be related to the fact that girls become mature earlier than boys and consequently they are able to form preferences about education choices at earlier years than boys. If this the case it might suggest that more effective programs to stimulate girls' interests in STEM fields should be provided in earlier years than high school.

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**Appendix A**

**Table A1. Composition of the sample**

| Name of School | Anno | Treated | Type of school |
|---|---|---|---|
| **Spinelli** | 3 | Yes | Liceo Scientifico |
| **Spinelli** | 4 | No | Liceo Scientifico |
| **Bruno** | 3 | No | Liceo Scientifico |
| **Bruno** | 4 | No | Liceo Scientifico |
| **Bruno** | 4 | Yes | Liceo Scientifico |
| **Galilei-Ferraris** | 3 | Yes | Liceo Scientifico |
| **Galilei-Ferraris** | 4 | No | Liceo Scientifico |
| **Bosso-Monti** | 3 | No | IIS |
| **Bosso-Monti** | 4 | Yes | IIS |
| **Cattaneo** | 3 | Yes | Liceo Scientifico |
| **Cattaneo** | 4 | No | Liceo Scientifico |
| **Avogadro** | 3 | No | IIS |
| **Avogadro** | 3 | Yes | IIS |
| **Avogadro** | 4 | No | IIS |
| **Copernico-Luxemburg** | 3 | No | IIS |
| **Copernico-Luxemburg** | 3 | Yes | IIS |
| **Copernico-Luxemburg** | 4 | Yes | IIS |
| **Blaise Pascal – Giaveno** | 3 | No | Liceo Scientifico |
| **Blaise Pascal – Giaveno** | 4 | Yes | Liceo Scientifico |
| **Porporato – Pinerolo** | 3 | No | Liceo Scientifico |
| **Porporato – Pinerolo** | 3 | Yes | Liceo Scientifico |
| **Porporato – Pinerolo** | 3 | Yes | Liceo Scientifico |
| **Porporato – Pinerolo** | 4 | No | Liceo Scientifico |
| **Porporato – Pinerolo** | 4 | Yes | Liceo Scientifico |
| **Botta – Ivrea** | 3 | No | Liceo Scientifico |
| **Botta – Ivrea** | 3 | No | Liceo Scientifico |
| **Botta – Ivrea** | 3 | Yes | Liceo Scientifico |
| **Botta – Ivrea** | 4 | Yes | Liceo Scientifico |

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