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Hacking Gender Stereotypes: Girls' Participation in Coding Clubs[†]

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Employment opportunities and wage growth are rising more rapidly among occupations that require high levels of both math and social skills (Deming 2017; Fayer, Lacey, and Watson 2017). The limited participation of women in science, technology, engineering, and mathematics (STEM) and coding is still a widespread phenomenon that may result in an insufficient supply of skills required in the labor market (Kahn and Ginther 2017; Adams and Kirchmaier 2016). To mitigate this issue, a number of initiatives around the world are trying to promote STEM education among female students or adult women (Del Carpio and Guadalupe 2021; Breda et al. 2021). Yet, there is limited evidence on the take-up of these interventions and the effectiveness of these projects in increasing the participation of women and reducing the gender gaps in STEM.

Gender gaps in math start to emerge during childhood and are exacerbated during adolescence, especially in countries with stronger gender stereotypes (Guiso et al. 2008; Nollenberger, Rodríguez-Planas, and Sevilla 2016). Several factors have been shown to influence women's academic self-concept and choice of field of study (Nosek, Banaji, and Greenwald 2002), including parenting (Carlana and Corno 2021; Chise, Fort, and Monfardini 2019; Tungodden and Willén 2019), teachers' expectations (Carlana 2019; Alan, Ertac, and Mumcu 2018), and peers (Brenøe and Zölitz 2020; Anelli and Peri 2019). Middle school is a key stage of the educational career of students: their identity is still malleable (Riegle-Crumb, Moore, and Ramos-Wada 2011), but students (and their families) are often making educational decisions with strong implications for their future, especially in countries characterized by early tracking in high school (Giustinelli 2016). While girls who self-select into scientific training and coding courses may be less prone to stereotypic influences and have higher math achievements (Ertl, Luttenberger, and Paechter 2017), it is unclear whether targeting other individuals should be preferred, as the returns in the skills acquired may be limited for girls with low pretreatment skills and interests (Di Tommaso et al. 2021). Identifying the characteristics associated with the take-up of these types of programs is of crucial importance for designing effective policies to address gender gaps in STEM.

In this paper, we focus on a project aimed at fostering the coding and social skills of girls called Girls Code It Better (GCIB), implemented in Italy. We analyze gender gaps in academic interests and the perception of barriers to achieving their own career goals, as well as how girls applying to the coding clubs differ from those that decide not to apply. First, we show that there are substantial gaps in academic interests beginning in middle school, with girls being less interested in STEM compared to boys despite their higher willingness to attend university. Girls are also more likely to perceive their gender and their ability as barriers to achieving their educational goals. Second, we show that girls who self-select into a coding club are different from other girls: in our sample, we can rule out substantial differences in parental education and occupation that may affect take-up, but girls applying to coding

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clubs have higher interest in pursuing STEM, and they are more likely to perceive their own gender as a barrier for their educational goals. Programs aimed at increasing girls' interest in STEM may be effective in closing the gender gap if they manage to "hack" the gender stereotypes and perceived barriers of high-achieving girls.

The rest of the paper is organized as follows. First, we briefly describe the program and the sample. In the second section we analyze the gender gaps in field interests. Finally, we compare the characteristics of girls who decide to enroll into coding clubs with those who decide not to sign up. We conclude with a discussion on how coding clubs may help with "hacking gender stereotypes."

I. Data and Experimental Design

A. *Program Description*

The GCIB program was designed by a private employment agency in Italy and has been implemented since 2014. It is aimed at mitigating gender gaps in the field of study and the workplace by promoting coding skills for girls. The intervention follows the pedagogical principles of project-based learning (Zecchi 2012; Condliffe 2017), with an approach based on "teaching by projects" to foster coding and the learning of new technologies (such as 3-D printing, robotics, and web and app design) as well as creative thinking and organizational and communication skills. To mitigate gendered subject choice and dynamics that perpetuate gender stereotypes, the intervention is implemented in a single-sex environment (Giardili 2019). Each coding club includes 20 girls (between 11 and 14 years old) attending the same middle school, a teacher from the school, and a technology expert (coach maker). Teachers and coach makers receive specific training and a manual describing the program protocols, along with centralized support during program development. They act as facilitators of learning rather than instructional teachers, promoting problem solving and encouraging students' motivation. GCIB is offered free of charge to all participating girls and is implemented in the afternoon at school for around 45 hours per school year. Since 2014, the project has involved around 6,100 girls enrolled in middle schools in most Italian regions.

B. *Sample and Experimental Design*

Since 2018, we have collaborated with our implementing partner (Fondazione Officina Futuro) to quantitatively assess the participation and effectiveness of GCIB. Participation in the program is voluntary, but it is limited to 20 girls per school by the resources of the implementing partner and the specific features of the instructional approach. When the number of applicants in a school exceeds 20, the slots are randomly assigned at individual level, stratified by grade. The compliance rate with the treatment is around 95 percent among students invited to participate in the project, suggesting that girls are highly involved in the development of the project.

We collect end line surveys of all students in schools with rationing, including detailed information on their family background, aspirations, interests, and perceptions of barriers to achieving career goals. In this paper, we focus on the pilot data collection in 2019, before the COVID-19 pandemic, due to limited sample size in the online surveys collected in 2020 and 2021. The sample includes 16 middle schools and 4,494 students. More information on the data collection and survey questions is available in Carlana and Fort (2022). In the analysis reported in this paper, to ease the interpretation, we transform Likert scales into dummies that assume a value of 1 if the value reported by the student is higher than the mean of the entire sample.

II. Gender Gaps

We start by comparing the characteristics of boys and girls in schools that participate in the program. As shown in the first three columns of Table 1, all family background characteristics are balanced (panel A), but 70 percent of girls are interested in applying to university compared to only 54 percent of boys. Panel B shows clear gender gaps in academic interests: boys are significantly more likely than girls to like math and have higher interest in STEM-oriented high schools and occupations (such as becoming an engineer, programmer, or scientist). On the other hand, girls are statistically more likely to like literature and are more interested in classical high school and non-STEM occupations (such

Table 1—Summary Statistics by Gender and Program Enrollment

Variable	Boys	Girls	*P*-value	Girls: applied		*P*-value
				No	Yes	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Family background						
Immigrant	0.165	0.181	0.142	0.190	0.061	0.006
	(0.371)	(0.385)		(0.392)	(0.240)	
Mother less than high school	0.557	0.573	0.405	0.582	0.545	0.396
	(0.497)	(0.495)		(0.493)	(0.500)	
Mother has a university degree	0.442	0.426	0.403	0.418	0.455	0.391
	(0.497)	(0.495)		(0.493)	(0.500)	
Mother works in STEM	0.149	0.139	0.426	0.133	0.148	0.756
	(0.356)	(0.346)		(0.340)	(0.357)	
Mother has a high wage	0.654	0.653	0.916	0.648	0.717	0.143
	(0.476)	(0.476)		(0.478)	(0.453)	
Father less than high school	0.593	0.613	0.249	0.614	0.626	0.913
	(0.491)	(0.487)		(0.487)	(0.486)	
Father has a university degree	0.406	0.386	0.261	0.386	0.374	0.919
	(0.491)	(0.487)		(0.487)	(0.486)	
Father works in STEM	0.283	0.287	0.729	0.282	0.337	0.246
	(0.451)	(0.452)		(0.450)	(0.475)	
Father has a high wage	0.582	0.582	0.823	0.582	0.576	0.945
	(0.493)	(0.493)		(0.493)	(0.497)	
Panel B. Academic interests						
Plans: university	0.543	0.700	0.000	0.691	0.707	0.454
	(0.498)	(0.458)		(0.462)	(0.457)	
Likes math	0.479	0.384	0.000	0.365	0.434	0.128
	(0.500)	(0.486)		(0.482)	(0.498)	
Likes Italian	0.302	0.440	0.000	0.439	0.404	0.293
	(0.459)	(0.496)		(0.496)	(0.493)	
STEM high school	0.415	0.372	0.004	0.354	0.444	0.042
	(0.493)	(0.484)		(0.478)	(0.499)	
Classic high school	0.494	0.707	0.000	0.708	0.758	0.366
	(0.500)	(0.455)		(0.455)	(0.431)	
STEM occupations	0.547	0.334	0.000	0.308	0.374	0.079
	(0.498)	(0.472)		(0.462)	(0.486)	
Non-STEM occupations	0.436	0.460	0.091	0.468	0.404	0.261
	(0.496)	(0.499)		(0.499)	(0.493)	
Panel C. Barriers to achieve educational goals						
Barrier: gender unfit	0.410	0.535	0.000	0.533	0.657	0.018
	(0.492)	(0.499)		(0.499)	(0.477)	
Barrier: math ability	0.349	0.437	0.000	0.444	0.434	0.687
	(0.477)	(0.496)		(0.497)	(0.498)	
Explicit gender stereotypes	0.557	0.344	0.000	0.351	0.354	0.725
	(0.497)	(0.475)		(0.477)	(0.480)	
Observations	2,244	2,250		1,885	99	

Notes: This table presents the summary statistics of the sample: column 1 shows the mean for boys, column 2 the mean for girls, and column 3 the difference between the two groups, including school fixed effects. Columns 4 and 5 show the mean for girls who did not apply to the program and girls in the control group of the intervention, respectively. The last column shows the *p*-value of the difference between girls who did not apply and girls who applied, controlling for school fixed effects. The standard deviation are in parentheses. In column 5, we consider only girls who apply to the coding course but are not selected to participate, as data were collected at end line for all students. Hence, the sum of observations in columns 4 and 5 is lower than the number of observations in column 2. Variables in panel B and C are dummies that assume value 1 if the value of the variable is higher than the mean in the sample, except for "Plans: university."

as lawyer or administrative staff). Furthermore, girls are more likely to perceive their own gender and their ability in math as obstacles to achieving their educational goals.[1]

III. Girls' Participation Decisions

The last three columns of Table 1 show the mean of each characteristic for girls who applied and did not apply to the GCIB program as well as the *p*-value of the difference when controlling for school fixed effects. Overall, 16 percent of girls in the schools applied to join the coding clubs, as they require an intensive effort after the end of the school day for around 45 hours total between November and April.[2] Girls applying to the coding club are less likely to be immigrants, and they have parents with lower education and occupation levels, although the difference is not statistically significant at conventional levels. The key difference between the two groups is related to their educational and occupational interests: girls applying to the coding clubs are more likely to report interest in math and continue their studies into a STEM-oriented high school and get a STEM-oriented occupation. However, even among applicants to coding clubs, the share of girls with a high interest in a STEM occupation is still 37 percent compared to an average of 55 percent among boys, suggesting important margins that affect their career choices. Notably, reaching self-selected applicants does not substantially reduce the potential for closing the gender gap in interest in a STEM occupation, as most of these girls still perceive high barriers and are unsure of whether to enroll in further STEM education.[3] At the same time, targeting self-selected candidates offers potential gains: as research on active learning programs suggests (Di Tommaso et al. 2021), it may indeed lead to improved program effectiveness on participants and overall cost effectiveness. Furthermore, girls who decided to apply to the coding clubs are more likely than other girls to perceive higher barriers to achieving their educational goals due to their own gender. As early as middle school, a substantial share of girls already perceive their own gender as a barrier to a successful career.

IV. Conclusion

Programs aimed at increasing the participation of girls in STEM education are likely to target girls less affected by gender-stereotypical influences in the field of study (Ertl, Luttenberger, and Paechter 2017). In this paper, we show that although girls who apply to a coding club have higher interest in STEM compared to other girls who do not apply, there is still a high share that can be persuaded to change their long-term career by decreasing their perception of own gender as a barrier to achieve their goals. Given the evidence on the effectiveness of intervention aimed at increasing the participation of girls in math, they may also be those with the highest potential gain from exposure to STEM (Di Tommaso et al. 2021). There is still a long way to go to close gender gaps, but education programs aimed at increasing the STEM participation of girls are a promising avenue to achieving this goal.

[1] As explained in Section IB, all variables in panels B and C of Table 1 are dummies that assume a value of 1 if the student reports an interest or a barrier perception higher than the mean student in the sample. The only exception is "Plans: university," which assumes a value of 1 if the student reports that his or her educational goal is to achieve a university degree. As students are invited to report their interest in different available types of high school (e.g., classic versus STEM) and not to submit their personal ranking across alternatives, answers are not mutually exclusive and do not sum to one.

[2] Given that we use data collected at end line, to avoid confounding the effect of the treatment with the self-selection, in column 5, we include only girls who applied but were not randomly selected to participate in the program.

[3] In our case, for example, the interest in STEM occupations for self-selected candidates is 7 percentage points higher than it is for other candidates (0.37 percent versus 0.30 percent).

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