

How Effective are Female Role Models in Steering Girls towards STEM? Evidence from French High Schools

How Effective are Female Role Models?

Thomas Breda^{1,*}, Julien Grenet^{1,**}, Marion Monnet^{2,§}, and Clémentine Van Effenterre^{3,‡}

Abstract: We show in a large-scale field experiment that a brief exposure to female role models working in scientific fields affects high school students' perceptions and choice of undergraduate major. The interventions reduce the prevalence of stereotypical views on jobs in science and gender differences in abilities, and make high-achieving girls in Grade 12 more likely to enrol in selective and male-dominated STEM programs in college. Leveraging the diversity of profiles of the 56 role models, we show that the most effective interventions are those that improved students' perceptions of STEM careers without overemphasizing women's under-representation in science.

Keywords: role models; gender gap; STEM; stereotypes; choice of study

Classification: C93, I24, J16

** **Correspondence address:** julien.grenet@psemail.eu

§marion.monnet@u-bourgogne.fr

‡c.vaneffenterre@utoronto.ca

*thomas.breda@ens.fr

A previous version of this paper was circulated under the title "Do Female Role Models Reduce the Gender Gap in Science? Evidence from French High Schools."

The increase in women's participation in science and engineering in the U.S. has leveled off in the past decade (National Science Foundation, 2017). This trend, which is common to almost all OECD countries, is a source of concern for two main reasons. First, it exacerbates gender inequality in the labour market, as Science, Technology, Engineering, and Mathematics (STEM) occupations offer higher average salaries (Brown and Corcoran, 1997; Black *et al.*, 2008; Blau and Kahn, 2017) and are characterized by a smaller gender wage gap (Beede *et al.*, 2011). Second, in a context of heightened concern over a shortage of STEM workers in the advanced economies, this trend is likely to represent a worsening loss of talent that could reduce aggregate productivity (Weinberger, 1999; Hoogendoorn *et al.*, 2013).

The under-representation of women in these traditionally male-dominated fields can also constitute a self-fulfilling prophecy for subsequent generations, as girls have little opportunity to interact with women who work in these fields and who could inspire them. A large literature has established that exposing female students to successful or admirable women can help break this vicious circle. Most of the work to date focuses on potential role models who interact on a regular basis with the individuals they may influence, such as teachers or instructors (Bettinger and Long, 2005; Carrell *et al.*, 2010; Lim and Meer, 2017), university advisors (Canaan and Mouganie, 2021), or doctors (Riise *et al.*, 2022). Recently, however, two studies have shown that a one-off exposure to external female role models can also have significant effects on female representation in male-dominated fields of study. Porter and Serra (2020) document a positive impact of two female role models who were carefully selected among the economics alumnae of Southern Methodist University in the U.S. on the likelihood of female students majoring in economics. Del Carpio and Guadalupe (2021) demonstrate the effectiveness, relative to other types of intervention, of a virtual role model in reducing identity costs related to female participation in STEM and fostering female applications to a software-coding program.¹ An attractive feature of these light-touch interventions for identifying role model effects is that they remove the influences of potential confounding factors such as gender differences in teaching practices (Lavy and Sand, 2018; Carlana, 2019; Terrier, 2020).

While the studies by Porter and Serra (2020) and Del Carpio and Guadalupe (2021) furnish compelling evidence that external role models can affect female students' educational choices, little is known about what

¹Related studies outside the context of STEM education include field experiments on exposure to women in leadership positions in India (Beaman *et al.*, 2012) and the provision of information on the returns to education by role models of poor or rich background in Madagascar (Nguyen, 2008).

drives their success, and it is unclear whether different role models are equally able to influence students' decisions. This paper addresses these questions by evaluating the impact of one-hour in-class interventions by women scientists. Our key contribution is to characterize what makes for an effective role model intervention. We investigate the attributes of role models and the messages they convey that are more likely to appeal to young women's perceptions and to trigger their interest in traditionally male-dominated fields. Two distinctive aspects of our setting make it particularly well suited to address this question. First, we use a large-scale randomized experiment on a diverse student population, exploiting both a rich post-intervention survey and comprehensive administrative data to measure directly how role models affect students' perceptions, beliefs and enrolment outcomes. Second, unlike previous studies, our research design involves a large number of role model participants—56 in all. We leverage the diversity of these women's profiles to better understand what makes an effective role model.

The program we evaluate is called “For Girls in Science”, launched in 2014 by the L'Oréal Foundation—the corporate foundation of the world's leading cosmetics manufacturer—to encourage girls to explore STEM career paths. It consists of one-hour in-class interventions by women with two quite distinct profiles: half are young scientists (either Ph.D. candidates or postdoctoral researchers) who were awarded the L'Oréal-UNESCO Fellowship “For Women in Science”; the others are young professionals employed as scientists in the Research and Innovation division of the L'Oréal group. In the main part of the intervention, the role models share their experience and career path with the students. They also provide information on science-related careers in general and on gender stereotypes, using two short videos.

The evaluation was conducted during the 2015/16 academic year in 98 high schools in the Paris region. It involved 19,451 students from Grade 10 and Grade 12 (science track), two grade levels at the end of which students make irreversible educational choices. Half of the classes were randomly selected to be visited by one of the 56 role model participants, who were assigned to those classes through a registration process on a first-come, first-served basis.

The role models' interventions led to a significant increase in the share of girls enrolling in STEM fields, but only in the educational tracks where they are severely under-represented. In Grade 10, the classroom visits had no detectable impact on boys' and girls' probability of enrolling in the science track in Grade 11,

where girls are only slightly under-represented (47% of students). In Grade 12, by contrast, the intervention induced a significant increase in the share of female students enrolling in selective STEM undergraduate programs, which lead to the most prestigious graduate schools, and in male-dominated STEM programs (maths, physics, computer science, and engineering).² The visits increased enrolment by respectively 3.1 and 3.4 percentage points (p.p.) in selective and male-dominated programs among girls in Grade 12, or increases of 28 and 20% over the baseline rates of 11 and 17%. These effects are concentrated among high-achieving girls in maths. Although we cannot formally reject the equality of gender coefficients, the effects for boys are small in magnitude and not statistically significant. These results constitute the first field evidence that in-person exposure to external female role models directly influences STEM enrolment decisions at college entry.

To explore the channels through which role models affect students' enrolment outcomes, we conducted a post-treatment student survey consisting of an eight-page questionnaire administered in class between one and six months after the classroom interventions. We also collected administrative data on high school graduation exams (*Baccalauréat*) at the end of Grade 12. Our results show that the role model interventions significantly improved students' perceptions of science-related jobs at both grade levels, with no indication of declining effects over a period of up to six months. They also helped mitigate some of the stereotypes typically associated with STEM occupations (such as the difficulty of reconciling them with family life) and heightened the perception that these jobs pay better. By contrast, the interventions had no significant effect on students' self-reported taste for science subjects or their academic performance, and bolstered the girls' self-concept in maths only slightly, at either grade level.

One of the most interesting—and unexpected—findings concerns the effects on students' perceptions of gender roles in science. Not only were the classroom interventions effective in debiasing students' beliefs about gender differences in maths aptitude, they also raised awareness of the under-representation of women in science. The combination of these two effects triggered an unintended ex-post rationalization by students of the gender imbalance in scientific fields and occupations, making them more likely to agree with the

²We classify STEM programs as being male-dominated if the share of female students is less than 50% (see Appendix A for details). Note that male-dominated and selective STEM programs are partly overlapping: in 2016/17, 49% of undergraduate students in male-dominated STEM fields were enrolled in selective programs, while 95% of students in selective programs were in male-dominated STEM fields.

statements that women dislike science and that they face discrimination in science-related jobs. Explicitly correcting self-stereotyping beliefs (Coffman, 2014) and misperceptions about women's representation in science (Bursztyn and Yang, 2022) would thus appear to have generated more ambiguous perceptions among students than the intervention's gender-neutral messages about jobs and careers.

Finally, we highlight the importance of the role model's profile for the success of the intervention. We document a high degree of heterogeneity in treatment effects according to their professional background. Those employed by the sponsoring firm had a significantly greater effect on girls' probability of enrolling in selective STEM programs than the young researchers, even though the two sets of students they visited had similar observable characteristics. While the two groups of role models were equally effective in debunking the stereotype on gender differences in maths aptitude, we find clear evidence that those with a professional background were more effective in improving girls' perceptions of science-related jobs and elevating their aspirations for such careers. Conversely, they were less likely to reinforce students' beliefs that women are under-represented in science. Using machine learning methods, we provide further evidence that the most effective role models are those who managed to convey a positive image of science careers and to stimulate students' aspirations without overemphasizing the relative scarcity of women and its possible causes. Together, these results show that role model interventions are not reducible to the provision of standardized information and that female role models are not interchangeable. They also highlight the mechanisms that likely explain the substantial effects that have been documented in other settings where career women serve as external role models (Porter and Serra, 2020).

The remainder of the paper is organized as follows. Section 1 provides institutional background on the French educational system and the gender gap in STEM fields. Section 2 describes the intervention and the experimental design. Section 3 presents the data and the empirical strategy. Section 4 analyses the effects of role model interventions on student perceptions, self-concept, aspirations, and educational outcomes. Section 5 extends the analysis to the role of information, the persistence of effects, and potential spillovers. Section 6 discusses what makes an effective role model intervention and Section 7 concludes.

1 Institutional Background

1.1 Structure of the French Education System

In France, education is compulsory from 6 to 16. The school year runs from September to June. The school system consists of five years of elementary education (Grades 1 to 5) and seven years of secondary education, divided into four years of middle school (*collège*, Grades 6 to 9) and three of high school (*lycée*, Grades 10 to 12). Students complete high school with the national *Baccalauréat* exam, which they must pass for admission to higher education.

High school tracks. The tracking of students occurs at two critical stages (see Figure 1). At the end of middle school, about two-thirds of students are admitted to general and technical upper secondary education (*Seconde générale et technologique*) and the remaining third are tracked into vocational schools (*Seconde professionnelle*). After the first year of high school (Grade 10), the general and technical track is further split: approximately 80% of the students are directed to the general *Baccalauréat* program for the last two years of high school (Grades 11 and 12), and the other 20%, mostly low-achieving students, are directed towards a technical *Baccalauréat*, which is more geared towards the needs of business and industry and leads to shorter studies.

In the Spring term of Grade 10, the students who have been allowed to pursue the general track are required to choose among three sub-tracks in Grade 11: Science (*Première S*), Humanities (*Première L*), and Social sciences (*Première ES*). This is an important choice, given that the curriculum and high school examinations are specific to each *Baccalauréat* track and thus have a direct impact on students' educational opportunities and career prospects. It is almost impossible, for instance, for a student to be admitted to engineering or medical undergraduate programs without a *Baccalauréat* in science. Students directed to the technical track after Grade 10 are also required to choose among eight possible STEM and non-STEM sub-tracks, which will affect their field of study in higher education.

College entry. In the Spring term of Grade 12, students in their final year of high school apply for admission to higher education programs through a centralized online admission platform. The programs

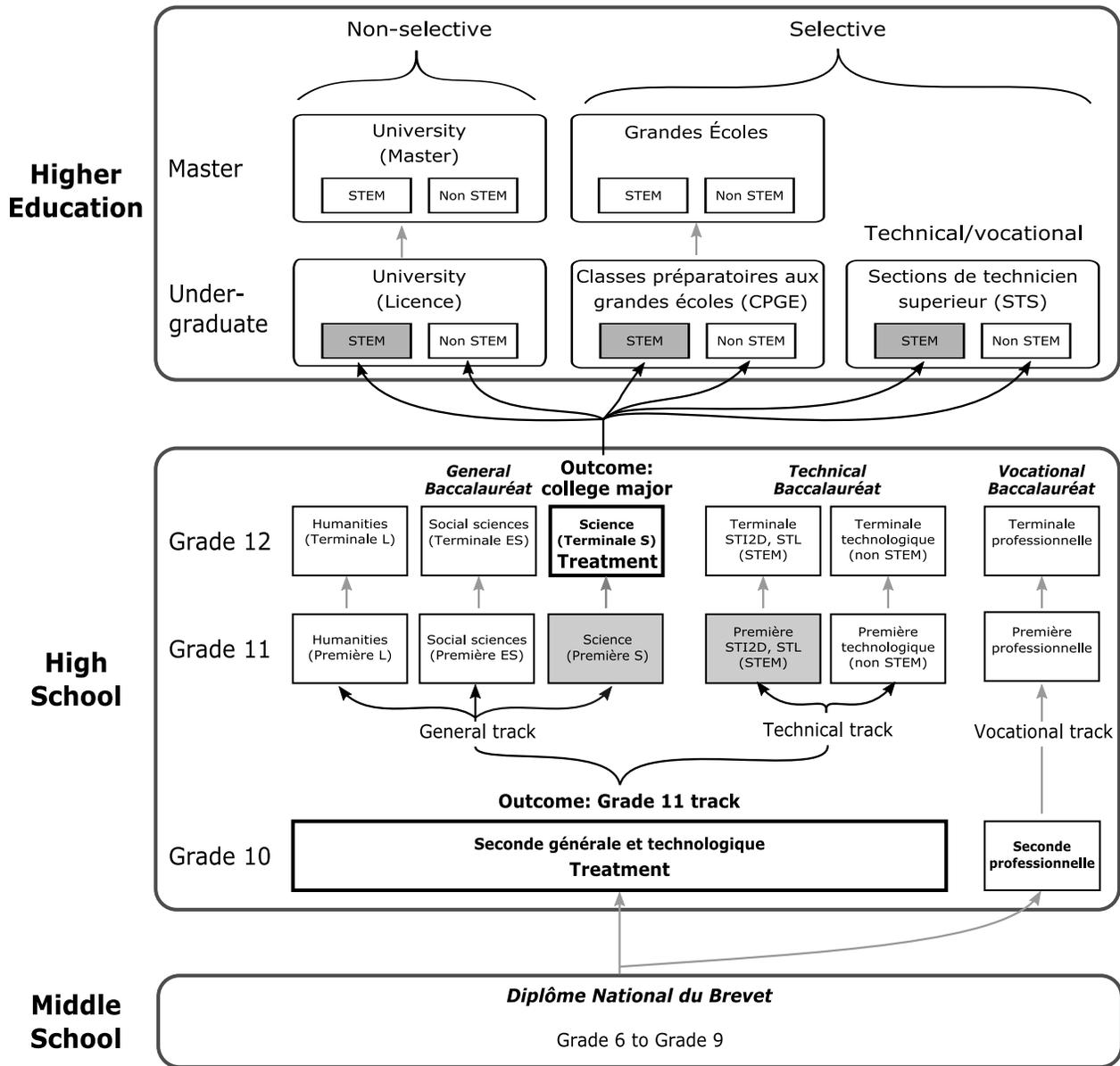


Figure 1. Tracks in Secondary and Post-Secondary Education in France

to which students can apply fall into two broad categories, each accounting for about half of first-year undergraduate enrolment: (i) non-selective undergraduate university programs (*Licence*), which are open to all students who hold the *Baccalauréat*; and (ii) selective programs, which can admit or reject students based on their academic achievement. Both types of program offer specializations in STEM and non-STEM fields. The most prestigious selective programs are the two-year *Classes préparatoires aux Grandes Écoles* (CPGE), which prepare students to take the national entry exams to elite graduate schools (*Grandes Écoles*). These programs are specialized either in science, in economics and business, or in humanities. Within the science CPGE programs, the main fields of specialization are mathematics and physics (MPSI), physics and chemistry (PCSI), and biology/geoscience (BCPST). The other selective undergraduate programs (*Section de technicien supérieur* or STS) are mostly targeted to students holding a vocational or technical *Baccalauréat* and prepare for technical/vocational bachelor's degrees.

1.2 Female Under-Representation in STEM

In France, the share of female students in STEM-oriented studies starts to decline after Grade 10 and drops sharply at entry into higher education. While 54% of the students in the general and technical track in Grade 10 are girls, the share falls to 47% in the general science track (Grades 11 and 12) and then plummets to 30% in the first year of higher education.³ Female under-representation in STEM fields of study is more pronounced in the selective undergraduate programs (shares of 18% in STS and 30% in CPGE) than in the non-selective programs (35%). These proportions, which are derived from administrative data for 2016/17, are almost identical to those of a decade earlier. Within STEM fields, female students tend to specialize in earth and life sciences (female share: 62%) rather than mathematics, physics, or computer science (female share: 26%).

The under-representation of women in STEM fields accounts for a good part of the gender pay gap among university graduates in France. Using a variety of administrative and survey data sources, we show that across all majors, male graduates who obtained a master's degree in 2015 or 2016 earn a median gross annual starting salary of €32,122, compared to €28,411 for female graduates (Appendix A). This gap of €3,711 per

³At the high school level, the gender imbalance in STEM is much more severe in the technical track (female share: 17%) than in the general science track (female share: 47%).

year is equal to 11.6% of men’s pay (see Table A1). Using standard decomposition methods, we find that the under-representation of female students in STEM accounts for approximately 28% of this gap (see Table A2). Additionally, almost half of the 9.1% gender pay gap within STEM can be ascribed to the fact that female graduates are less likely than males to be enrolled in the selective and male-dominated fields, which lead to the best-paying degrees. These figures strongly suggest that, in the French context, increasing the share of female students in STEM—especially in selective and male-dominated programs—would narrow the gender pay gap substantially.

2 Program and Experimental Design

2.1 “For Girls in Science”

The program “For Girls in Science” (FGiS) is an awareness campaign launched in 2014 by the L’Oréal Foundation to encourage girls to explore STEM career paths. It consists of one-hour one-off classroom interventions by female role models with a background in science. The interventions, which take place in the presence of all students in the class, including boys, are made by female role models of two distinct types: (i) Ph.D. candidates or postdoctoral researchers who have been awarded a fellowship by the Foundation (the L’Oréal-UNESCO “For Women in Science” Fellowship) and who participate in the program as part of their contract; and (ii) young scientists employed in the Research and Innovation division of the L’Oréal group who volunteer for the program.

Structure and content of the interventions. The classroom interventions last one hour and are divided into four main sequences. Each role model was given a set of slides as a support for the in-class conversation. During the first sequence, a few slides highlight two facts: (1) the labour market is marked by high demand for STEM skills and there is a shortage of graduates in the relevant fields of study; and (2) women are under-represented in STEM careers. To investigate the role of information provision, we gave 36 of the 56 role models additional slides that they were free to use during this sequence. They supplied supplementary information about average earnings and employment conditions in STEM jobs and were illustrated with

examples of career prospects in humanities versus science. In Section 5, we discuss the sensitivity of our results to this more intensive provision of standardized information.

The second sequence kicks off with two three-minute videos designed to set forth and deconstruct stereotypes about science-related careers and gender roles in science.⁴ The first video, entitled “Science, Beliefs or Reality?,” uses interviews with high school students to debunk myths about careers in science (e.g. jobs in science are more challenging, they necessarily require more years of schooling), stereotypes about scientists (e.g. they are introverted, lonely), and gender differences in science aptitude (e.g. women are naturally less talented in maths). The second video, entitled “Are we all Equal in Science?,” sets out the common gender stereotypes about science aptitude while providing information on brain plasticity and on how interactions and the social environment shape men’s and women’s abilities and tastes. This sequence seeks to stimulate class discussion based on students’ reactions.

The third sequence centres on the role model’s own experience as a woman with a background in science and consists of a question-and-answer session with the students.⁵ Topics addressed during this discussion include the role model’s typical day at work, what she enjoys about her job, the biggest challenge she had to overcome, how she views her professional future, her everyday interactions with co-workers, how much she earns, and her work-family balance. Consistent with the program’s emphasis on the role model dimension, this sequence was intended as the longest and most important part of the intervention. To convey this objective to the role models, a day-long training session was organized to help them share their experience with the students. The training also included a workshop on the under-representation of women in science and a practice session aimed at enhancing oral communication skills.

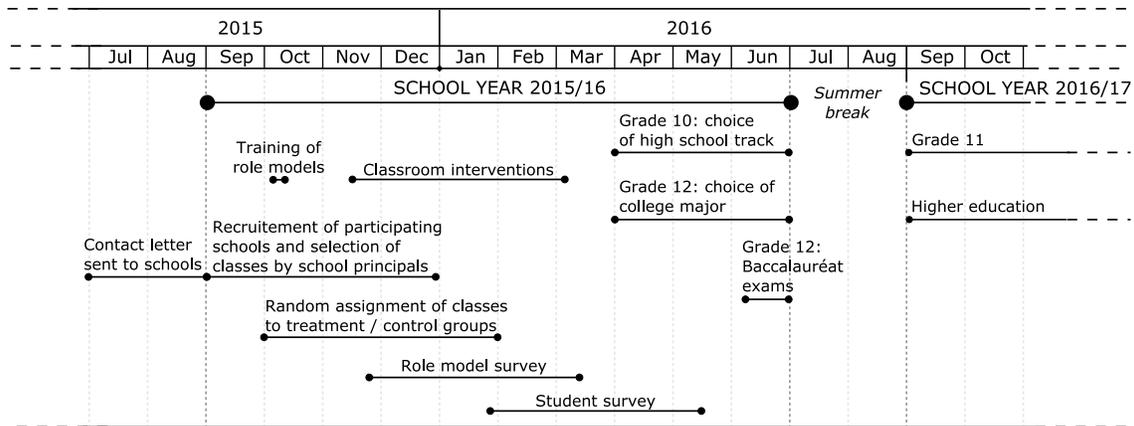
The intervention concludes with an overview of the diversity of STEM studies and careers, illustrated by concrete examples such as jobs in graphic design, environmental engineering, and computer science.

2.2 Experimental Design

Participating schools. The evaluation was conducted in the three school districts (*académies*) of the Paris region (Paris, Créteil, and Versailles) during the 2015/16 academic year. Créteil and Versailles are the two

⁴Screenshots of the two videos shown during the classroom interventions are displayed in Appendix Figure B1.

⁵Screenshots of the slides used during the discussion are shown in Appendix Figure B1.

Figure 2. *Program Evaluation Timeline*

largest districts in France and the three combined include 318,000 high school students in the general and technical track, or 20% of all French high school enrolment.

Figure 2 shows the detailed timeline of the evaluation. In the spring of 2015, the French Ministry for Education agreed to support a randomized evaluation of the program and designated one representative for each district as intermediary between the schools and the evaluation team. In June, official letters informed the high school principals, who are in charge of extracurricular activities, that they were likely to be contacted to take part in the evaluation. All public and private high schools with at least four classes in Grade 10 and two in the Grade 12 science track were contacted by our team between September and December 2015, accounting for 349 of the 489 high schools in the three districts. Of these schools, 98 agreed to take part in the experiment, representing 28% of Grade 10 enrolment and 29% of Grade 12 science track enrolment in the three districts.⁶ The participating schools tend to be larger and are less likely to be private or to be in the Paris education district than the non-participants (see Appendix Table E1).

Selection of classes and randomization. In the fall of 2015, the principals were invited to select at least six classes—four or more in Grade 10 and two or more in Grade 12 science track—and to indicate a preferred time slot and day for the visits.⁷ While it is possible that principals selected classes where they expected the interventions to be more effective, Appendix Table E2 shows that selected and non-selected classes are broadly

⁶The location of the participating schools is shown in Appendix Figure B3. The high schools that declined to take part did so mainly because they feared the organizational burden of the classroom interventions.

⁷In a large majority of schools, principals selected exactly four Grade 10 and two Grade 12 classes.

comparable, lending support to the external validity of our experimental design. The gender composition of Grade 10 classes is similar between the two groups, while in Grade 12, the share of female students is slightly higher in the classes selected. Despite these differences, the experimental sample, which consists of 19,451 students (13,700 in Grade 10 and 5,751 in Grade 12), resembles the relevant student population quite closely, both in social composition and in average academic performance.

In each school, half of the classes selected (up to the nearest integer) were assigned randomly to the treatment group (302 classes in total) and the other half to the control group (299 classes). Table 1 indicates that while the random assignment successfully balanced the characteristics of students in the treatment and control groups in Grade 10, it did not achieve perfect covariate balance in Grade 12. In our empirical analyses, we account for these residual imbalances by controlling for students' baseline characteristics in our main specification.

Role models. The experiment involved 56 female role models: 35 L'Oréal employees and 21 Ph.D. candidates or postdoctoral researchers. Table 2 provides summary statistics of their characteristics. The researchers are younger (30 vs. 36 years of age on average) and less likely to be foreign nationals (10 vs. 17%). Although both types have very high educational attainment, 39% having graduated from a *Grande École*, the researchers, by definition, are more likely than the professionals to hold (or be preparing for) a Ph.D. (100 vs. 38%) and to hold a degree in maths, physics and engineering (38 vs. 14%). They are also less likely to have children (19 vs. 58%) and to have been involved in the program in the previous year (19 vs. 29%). The professionals working at L'Oréal are employed in various activities: chemistry (development of new technologies for skin products), logistics and supply chain management, statistics (consumer evaluation), immunology and toxicology. Although we could not collect direct information on earnings for reasons of confidentiality, based on aggregate information provided by the L'Oréal Group we estimate that the annual gross salary of these young professionals is between €45,000 and €65,000, compared with €22,000–€50,000 for the researchers. On average, the role models carried out five classroom interventions in two different high schools.

Table 1. *Treatment-Control Balance*

	Control group (1)	Treatment group (2)	Within school	
			Difference T-C (3)	<i>p</i> -value of diff. (4)
Panel A. Grade 10				
<i>Student characteristics</i>				
Female	0.535	0.522	-0.010	0.309
Age (years)	15.13	15.12	-0.01	0.180
Non-French	0.059	0.061	0.002	0.652
High SES	0.377	0.386	0.008	0.321
Medium-high SES	0.131	0.125	-0.007	0.168
Medium-low SES	0.248	0.235	-0.012	0.064
Low SES	0.244	0.254	0.012	0.085
Number of siblings	1.485	1.486	0.003	0.904
Class size	33.22	33.27	0.07	0.476
At least one science elective course	0.389	0.398	0.005	0.820
At least one standard elective course	0.770	0.737	-0.031	0.138
DNB percentile rank in maths	58.61	58.35	-0.35	0.533
DNB percentile rank in French	57.79	57.91	0.12	0.829
<i>Test of joint significance</i>	<i>F</i> -stat: 0.798 (<i>p</i> -value: 0.653)			
<i>Predicted track in Grade 11</i>				
Grade 11: Science track	0.449	0.452	0.001	0.922
Grade 11: Science - general track	0.373	0.375	0.001	0.920
Grade 11: Science - technical track	0.077	0.077	-0.000	0.989
N	6,801	6,899	13,700	
Panel B. Grade 12 (science track)				
<i>Student characteristics</i>				
Female	0.499	0.484	-0.014	0.292
Age (years)	17.14	17.11	-0.04	0.000
Non-French	0.053	0.048	-0.006	0.275
High SES	0.453	0.474	0.029	0.009
Medium-high SES	0.136	0.135	-0.001	0.829
Medium-low SES	0.216	0.201	-0.015	0.023
Low SES	0.195	0.190	-0.012	0.140
Number of siblings	1.510	1.487	-0.032	0.127
Class size	31.75	32.19	0.39	0.196
DNB percentile rank in maths	74.17	73.95	0.20	0.699
DNB percentile rank in French	69.31	69.90	0.89	0.122
<i>Test of joint significance</i>	<i>F</i> -stat: 0.983 (<i>p</i> -value: 0.459)			
<i>Predicted undergraduate major</i>				
Major: STEM	0.382	0.384	0.003	0.352
Major: selective STEM	0.175	0.178	0.006	0.081
Major: male-dominated STEM	0.273	0.276	0.004	0.279
N	2,853	2,898	5,751	

Notes: Each row corresponds to a different linear regression with the dependent variable listed on the left, separately for students in Grade 10 (Panel A) and in Grade 12 (Panel B). Columns 1 and 2 show the average value for students in the control and treatment groups, respectively. Column 3 reports the coefficient from the regression of each variable on the treatment group indicator, with the *p*-value reported in column 4. The regression controls for school fixed effects to account for the fact that randomization was stratified by school, and standard errors are adjusted for clustering at the unit of randomization (class). The *F*-statistic is from a test of the joint significance of the coefficients in a regression of the treatment group indicator on all student characteristics. High school tracks (Panel A) and undergraduate majors (Panel B) are predicted for each student using the coefficients from a linear regression of the corresponding binary variable (e.g. enrolment in a STEM major) on all student characteristics listed in the table. This model is fitted separately by grade level on the sample of students in the control group.

Table 2. *Female Role Models: Summary Statistics*

	All role models (1)	Researchers (Ph.D./ Postdoc) (2)	Professionals (employed by sponsoring firm) (3)
Age (N=51)	33.3 (5.7)	30.0 (3.1)	35.6 (6.0)
Non-French holds/prepares for a Ph.D. (N=55)	0.14 0.62	0.10 1.00	0.17 0.38
Graduated from a Grande École	0.39	0.33	0.43
Field: Maths, Physics, Engineering	0.23	0.38	0.14
Field: Earth and Life Sciences	0.64	0.62	0.66
Field: Other	0.13	0.00	0.20
Has children (N=52)	0.42	0.19	0.58
Participated in the program the year before	0.25	0.19	0.29
Number of high schools visited	1.8 (0.8)	2.1 (0.9)	1.6 (0.7)
Number of classroom interventions	5.2 (2.3)	5.9 (2.3)	4.7 (2.1)
Visited at least one high school in Paris	0.27	0.29	0.26
N	56	21	35

Notes: The summary statistics are computed based on information obtained from the L'Oréal Foundation and from the post-intervention survey administered online to collect feedback about the classroom visits. Standard deviations are shown in parentheses below the mean values. Where data are missing for some role models, the number of non-missing values N is indicated in parentheses.

Classroom interventions. The classroom visits took place between 17 November 2015 and 3 March 2016.⁸

The role models were asked to choose two or three schools in which to make an average of three classroom visits per school—in most cases, two in Grade 10 and one in Grade 12. They were not assigned to the schools randomly but registered for the visits and time slots on a first-come, first-served basis during four registration sessions using an online system. Randomly assigning the role models to the schools was not feasible, as most were participating on a voluntary basis and during regular working hours. We therefore gauge the causal impact of role models in a setting where they have some freedom to choose the schools in which they intervene. The assignment process, however, did not involve any coordination between the participants and was designed to limit their ability to select the schools they would visit, as each registration session only concerned a subset of the participating schools.⁹

⁸17% of the visits took place in November, 26% in December, 40% in January, 17% in February, and 1% in March (see Panel A of Appendix Table E9).

⁹The role models were contacted four times to complete the schedule, on 21 October, 24 November, 7 December 2015, and 3 February 2016.

3 Data and Empirical Strategy

3.1 Data

To evaluate the program’s effects on student perceptions and educational outcomes, we combine three main data sources: (i) a post-intervention survey of the role models; (ii) a post-intervention survey of the students; and (iii) student-level administrative data.¹⁰

Role model survey. After each visit to a school, the role models were invited to complete an online survey. Besides collecting general feedback, this survey served to monitor compliance with random assignment, asking them to indicate each of the classes they visited. Summary statistics are reported in Appendix Table E3. The interventions almost always (89%) took place in the presence of the teacher and sometimes (35%) of another adult. The role models reported organizational problems (e.g. the intervention started late, the slides could not be shown) for only 16% of the visits. According to the survey, researchers and professionals were equally likely to cover the intended topics, such as “jobs in science are fulfilling”, “they are for girls too”, and “they pay well.” Finally, when asked about their overall perception of their interventions, 93% gave positive assessments, saying they went “well” (37%) or “very well” (56%). Students were generally seen to have been responsive to the key messages.

Student survey. We conducted a paper-and-pencil student survey in the classes assigned to the treatment and control groups between one and six months after the classroom visits (January to May 2016). Each questionnaire had a unique identifier so that it could be linked with student-level administrative data. The survey was designed to collect a rich set of information on students’ preferences, beliefs and perceptions regarding science, self-concept, and aspirations. The questionnaire was anonymous and, to maximize the response rate and the quality of the responses, was administered in exam conditions under the supervision of a teacher (not necessarily the one present during the classroom visit). It was presented as a general survey on attitudes about science and science-related careers so as to minimize the risk that students would associate it

¹⁰The original and translated versions of the two surveys are provided in the replication package to this paper.

with the FGIS program and, therefore, reduce the scope for social desirability bias.¹¹ It was eight pages long and took about half an hour to complete.

The survey items are designed to measure the effects of the interventions on students' perceptions along five dimensions: (i) general perceptions of science-related careers; (ii) perceptions of gender roles in science; (iii) taste for science subjects; (iv) self-concept in maths; and (v) science-related career aspirations. When conceptually related, we combine the survey items to construct a composite index for each dimension using standardized z -score scales. Section 4 describes the specific items that are used for each dimension.¹²

As shown in Appendix Table E5, the survey response rates are high both in Grade 10 (88%) and in Grade 12 (91%). They are slightly higher among Grade 10 students in the treatment than in the control group (by 2.6 p.p.). Despite this small difference in response rates, the characteristics of survey respondents are generally balanced (see Appendix Table E6). In analysing survey-based outcomes, we control for students' characteristics at baseline to account for any residual imbalance between the treatment and control groups.

Administrative data. We linked the student survey data to a rich set of individual-level administrative data covering the universe of high school students in the Paris region from 2012/13 to 2016/17. These data provide detailed information on students' socio-demographic characteristics and enrolment status every year, allowing us to identify the track taken by Grade 10 students entering Grade 11.

The college enrolment outcomes of students in Grade 12 were obtained by matching the survey and administrative data for high school students with administrative microdata covering almost all the students enrolled in selective and non-selective higher education programs in 2016/17.¹³ These data are supplemented by comprehensive individual examination results from the *Diplôme National du Brevet* (DNB), which is taken at the end of middle school, and from the national *Baccalauréat* exam (for Grade 12 students). Specifically, we use students' grades on the final exams in French and maths (converted into national percentile ranks), as these tests are graded externally and anonymously. Further details on the data sources and the classification of higher education programs can be found in Appendix C.

¹¹In Section 5, we provide suggestive evidence against experimenter demand effects driving our findings.

¹²To attenuate potential order bias, the order of several of the response items (e.g. maths/French, man/woman) was set randomly.

¹³The programs not covered by these administrative data are those leading to paramedical and social care qualifications. Available estimates suggest that among Grade 12 students who obtained a *Baccalauréat* in Science in 2008, under 6% were enrolled in those programs the following year (Lemaire, 2012).

3.2 Empirical Strategy

Compliance with random assignment was not perfect: about 5% of the classes assigned to the treatment group were not visited by a role model, and 1% of the classes in the control group, instead, were mistakenly visited (see Appendix Table E4).¹⁴ To deal with this marginal two-way non-compliance, we follow the standard practice of using treatment assignment as an instrument for treatment receipt, which allows us to estimate the program’s local average treatment effect (LATE) instead of the average treatment effect (ATE). Specifically, we estimate the following model using two-stage least squares (2SLS):¹⁵

$$Y_{ics} = \alpha + \beta D_{cs} + \mathbf{X}_{ics}\pi + \theta_s + \epsilon_{ics}, \quad (1)$$

$$D_{ics} = \gamma + \delta T_{cs} + \mathbf{X}_{ics}\tau + \lambda_s + \eta_{ics}, \quad (2)$$

where Y_{ics} denotes the outcome of student i in class c and high school s , D_{cs} is a dummy variable indicating whether the student’s class received a visit, and T_{cs} is a dummy for assignment to the treatment group. The regression further includes the student characteristics \mathbf{X}_{ics} listed in Table 1 to control for residual imbalances between the treatment and control groups. Finally, school fixed effects, θ_s and λ_s , are included to account for the fact that the randomization was stratified by school and grade level.

The model specified by Equations (1) and (2) is estimated separately by grade level and gender, with standard errors clustered at the unit of randomization (class). To account for multiple hypotheses testing across the outcomes of interest, the treatment effect estimates are accompanied by adjusted p -values (q -values) in addition to the standard p -values.¹⁶

¹⁴We are confident that non-compliance was mostly due to organizational and logistical issues and was not an endogenous response to randomization. The few role models who carried out interventions in classes assigned to the control group or in classes not selected to participate in the evaluation generally reported that their interventions had been poorly organized, the person in charge often not being aware of the purpose of the visit. In some cases, classroom interventions were scheduled during another speciality course involving multiple classes, meaning that only some of the students in the treatment group were effectively treated.

¹⁵Because non-compliance concerned only a small fraction of classes, the LATE and intention-to-treat (ITT) estimates are very close in magnitude. The ITT estimates can be found in Appendix Table H1 (columns 1 and 4).

¹⁶We use the False Discovery Rate (FDR) control, which designates the expected proportion of all rejections that are type-I errors. Specifically, we use the sharpened two-stage q -values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). See Appendix D for details.

4 Effects of Classroom Interventions

We analyse the impact of the classroom interventions on three sets of student outcomes: (i) general perceptions of science-related careers and of gender roles in science; (ii) preferences, self-concept, and aspirations; and (iii) enrolment outcomes and academic performance.

4.1 Perceptions of STEM Careers and Gender Roles in Science

Students' post-intervention survey responses show that the classroom interventions were effective in challenging stereotyped views of science-related careers and gender roles. The results are reported in Table 3 for students in Grade 10 and in Table 4 for students in Grade 12.

Perceptions of science-related careers. Students were asked to agree or disagree with five statements on science-related careers relating to pay, the length of studies leading to these careers, work-life balance, and the two prevalent stereotypes that science-related jobs are monotonous and solitary. We build a composite index of "positive perceptions of science-related careers" by re-coding the Likert scales so that higher values correspond to less stereotyped or negative perceptions, before taking the average of each student's responses to the five questions. To facilitate interpretation, we normalize the index to have a mean of zero and a standard deviation of 1 in the control group.¹⁷ For closer investigation of the various aspects that might be captured by the overall index, we construct binary variables taking value 1 if the student agrees (strongly or somewhat) with each statement, and zero if he/she disagrees.¹⁸

One of the interventions' key objectives was to correct students' beliefs about jobs and careers in science by offering not only standardized information but also information specific to each role model's experience. As is shown in Panel A of Tables 3 and 4, the role model interventions significantly improved girls' and boys' perceptions of such careers as measured by the composite index. The treatment effect estimates range from 16% of a standard deviation for boys to around 30% for girls, with significantly stronger effects for female students in both grades.

¹⁷We checked that our results are robust to converting the item responses into binary variables before computing the indices as well as to using Bartlett factor scores instead of the procedure described in the text. See Appendix D for further details on the construction of the composite indices.

¹⁸Similar groupings are performed when using responses that are measured on a four-point Likert scale (usually concerning perceptions or self-confidence) so that the outcome variables can be directly interpreted as proportions. The results are not qualitatively affected by such grouping.

Table 3. *Impact of Role Model Interventions on Student Perceptions in Grade 10*

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Perceptions of science-related careers							
Positive perceptions of science-related careers (index)	−0.020	0.245*** (0.027)	0.000 [0.001]	0.023	0.162*** (0.027)	0.000 [0.001]	0.013
Panel B. Perceptions of gender roles in science							
More men in science-related jobs	0.628	0.154*** (0.013)	0.000 [0.001]	0.629	0.170*** (0.014)	0.000 [0.001]	0.345
Equal gender aptitude for maths (index)	0.115	0.111*** (0.024)	0.000 [0.001]	−0.134	0.142*** (0.030)	0.000 [0.001]	0.383
Women don't really like science	0.157	0.056*** (0.011)	0.000 [0.001]	0.198	0.101*** (0.013)	0.000 [0.001]	0.002
W face discrimination in science-related jobs	0.603	0.126*** (0.013)	0.000 [0.001]	0.527	0.154*** (0.014)	0.000 [0.001]	0.102
Panel C. Stated preferences, self-concept, and aspirations							
Taste for science subjects (index)	−0.169	−0.033 (0.031)	0.275 [0.414]	0.197	−0.021 (0.026)	0.431 [0.555]	0.704
Self-concept in maths (index)	−0.198	−0.001 (0.028)	0.981 [0.982]	0.231	0.033 (0.029)	0.250 [0.375]	0.324
Science-related career aspirations (index)	−0.103	0.005 (0.029)	0.851 [0.970]	0.120	0.004 (0.027)	0.871 [0.872]	0.977
N		6,475			5,751		

Notes: This table reports estimates of the treatment effects of the role model interventions on the perceptions of students in Grade 10. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). The *q*-values are adjusted for multiple testing across the study's nine main outcomes of interest, separately by grade level and gender (see Appendix ?? for details). The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. *Impact of Role Model Interventions on Student Perceptions in Grade 12 (Science Track)*

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Perceptions of science-related careers							
Positive perceptions of science-related careers (index)	−0.003	0.296*** (0.032)	0.000 [0.001]	0.003	0.171*** (0.033)	0.000 [0.001]	0.002
Panel B. Perceptions of gender roles in science							
More men in science-related jobs	0.712	0.122*** (0.016)	0.000 [0.001]	0.717	0.149*** (0.015)	0.000 [0.001]	0.166
Equal gender aptitude for maths (index)	0.158	0.078*** (0.028)	0.004 [0.007]	−0.161	0.124*** (0.042)	0.003 [0.006]	0.348
Women don't really like science	0.074	0.042*** (0.009)	0.000 [0.001]	0.146	0.073*** (0.015)	0.000 [0.001]	0.079
W face discrimination in science-related jobs	0.624	0.085*** (0.020)	0.000 [0.001]	0.600	0.074*** (0.018)	0.000 [0.001]	0.651
Panel C. Stated preferences, self-concept, and aspirations							
Taste for science subjects (index)	−0.002	0.018 (0.033)	0.583 [0.583]	0.002	0.014 (0.040)	0.733 [0.825]	0.924
Self-concept in maths (index)	−0.184	0.051 (0.035)	0.139 [0.157]	0.187	0.068** (0.033)	0.038 [0.057]	0.695
Science-related career aspirations (index)	−0.045	0.106*** (0.037)	0.004 [0.007]	0.046	0.068* (0.035)	0.055 [0.071]	0.410
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on the perceptions of students in Grade 12 (science track). The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). The *q*-values are adjusted for multiple testing across the study's nine main outcomes of interest, separately by grade level and gender (see Appendix ?? for details). The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The detailed results for the different components of the index are reported in Appendix Table F1. Students' baseline perceptions indicate relatively widespread negative stereotypes about careers in science (see columns 1 and 4), with little difference between boys and girls or between grade levels. As an example, between 17 and 33% of students consider that science-related jobs are monotonous or solitary. A significant impact of the classroom visits is observed for almost all the components of the index. The largest effects relate to the statements "science-related jobs require more years of schooling" and "science-related jobs are rather solitary," two stereotypes that were explicitly debunked in the slides and videos. Although the effects are not strikingly different between genders and grade levels, they tend to be greater for girls in Grade 12. In particular, the interventions significantly reinforced female students' perception that science-related careers are compatible with a fulfilling family life, a message specifically conveyed by the role models and in line with the evidence showing that jobs in science and technology enable women to work more flexibly (Goldin, 2014).

Perceptions of gender roles in science. Female under-representation in STEM can be broadly attributed to three possible causes: gender differences in abilities, discrimination (on the demand side), and differences in preferences and career choices (on the supply side). The survey questions were designed to capture students' views on these three dimensions.¹⁹

Strikingly, the results show that more than a third of Grade 10 students and a quarter of Grade 12 students in the control group are not aware that women are under-represented in science-related careers (Panel B of Tables 3 and 4). These proportions do not differ greatly either by gender or by grade. For boys and girls in both grades, the interventions increased awareness of female under-representation in STEM by 12 to 17 percentage points. This is one of the strongest effects of the interventions.

The classroom interventions were also effective in debiasing students' beliefs about gender differences in maths aptitude. To capture this dimension, we asked students whether they agreed with the statements that "men are more gifted than women in mathematics" and that "men and women are born with different brains." We used these two questions to construct a composite index to gauge whether students believe that men and

¹⁹Unlike the survey questions related to students' perceptions of science-related careers, those on perceptions of gender roles in science are not aggregated into a single index because they were designed to capture different dimensions that cannot be easily combined. For the same reason, we refrained from using a single index to measure students' stated preferences, self-concept, and aspirations (see Section 4.2).

women have equal aptitude for mathematics. The results show significant rises in this index for both genders in both grades, with treatment effects ranging between 7.8% and 14.2% of a standard deviation.²⁰

Interestingly, the classroom visits had more ambiguous, partially unintended effects regarding the other two possible causes. First, when asked about gender differences in preferences, the share of students who agree that “women don’t really like science” is relatively low in the control group (16% of girls and 20% of boys in Grade 10; 7% of girls and 15% of boys in Grade 12), but it is substantially higher owing to the interventions for both genders, by 4 to 10 percentage points. Second, the baseline shares of boys and girls who say that women face discrimination in science-related jobs are much larger (between 53 and 62%); these too increase for both genders, by 7 to 15 percentage points. These unintended effects on students’ perceptions might represent an effort to rationalize the small number of women in science-related careers, making students more likely to agree with the simplistic view that “women don’t really like science” as well as subscribing to the idea that women face discrimination.

4.2 Stated Preferences, Self-Concept, and Aspirations

We now turn to the effects of the interventions on students’ taste for science subjects, their self-concept in maths, and their science-related career aspirations. The results are reported in Panel C of Tables 3 and 4.

Taste for science subjects. For both genders in Grade 10 and Grade 12, the classroom visits had no sizeable impact on students’ taste for science subjects, which we measure using an index that combines their answers to four questions about their enjoyment of maths, physics-chemistry, and earth and life sciences (on a 0 to 10 Likert scale), and their self-reported taste for science in general (on a 4-point Likert scale).²¹ These findings are not particularly surprising, given that the interventions did not expose students to science-related content and were not specifically designed to promote interest in science.

Self-concept in maths. To measure the impact of the classroom visits on students’ self-concept in mathematics, we use a composite index combining the responses to four questions: (i) students’ self-assessed performance in maths; (ii) whether they feel lost when trying to solve a maths problem; (iii) whether they

²⁰The detailed results for the two components of this index are reported in Appendix Table F2.

²¹The detailed results for the four components of the index are reported in Appendix Table F3.

often worry that they will struggle in maths class; and (iv) whether they think they can do well in science subjects if they make enough effort.

Consistent with the literature, our sample exhibits large gender differences in self-concept in mathematics. In the control group, the value of the index is 43% of a standard deviation lower for girls than for boys in Grade 10, and 37% lower in Grade 12. Large gender differences are found for most of the items used in the construction of this index, in particular those related to maths anxiety (see Appendix Table F4).

Although the interventions were light-touch, they did have some positive effect on students' self-concept in maths. These effects are statistically significant only for boys in Grade 12 when using the composite index. The interventions, however, consistently reduced the probability of students reporting worry that they will struggle in maths class. Point estimates tend to be higher for boys than for girls in both grades, indicating that the classroom interventions had no corrective effect on the substantial gender gap in this area.

Science-related career aspirations. The choice of a science-related career path does not depend solely on students' taste for the science taught at school. It also depends on their perceptions of the relevant jobs and their amenities, such as earnings, work/life balance, and the work environment, all of which were embodied by the role models.

To measure the effects on students' aspirations for science-related careers, we use a composite index combining the responses to four questions: (i) whether the students find that some jobs in science are interesting; (ii) whether they could see themselves working in a science-related job; (iii) whether they are interested in at least one of six STEM jobs out of a list of ten STEM and non-STEM occupations;²² and (iv) whether they consider career and earnings prospects as important factors in their choice of study.

Although the interventions had no discernable impact on Grade 10 students' science-related aspirations, in Grade 12 the effects are positive and statistically significant for both genders (11% of a standard deviation for girls, significant at the 1% level, and 7% for boys, significant at the 10% level). The more detailed results reported in Appendix Table F5 show that the interventions had significant positive effects on three of the relevant survey items for Grade 12 students. In particular, those in the treatment group are more likely to

²²The STEM occupations in the list were: chemist, computer scientist, engineer, industrial designer, renewable energy technician, and researcher in biology. The non-STEM occupations were lawyer, pharmacist, physician, and psychologist.

report that career and earnings prospects are important factors in their choice of study, which is consistent with the thesis that the interventions raised their awareness of the wage premium for STEM jobs.

4.3 Educational Choices and Academic Performance

High school track after Grade 10. Table 5 shows that the classroom visits had no significant impact on Grade 10 students' choice of track for the academic year following the intervention, i.e. 2016/17. For both genders, the treatment effect estimates are close to zero, whether we consider enrolment in any STEM track or in the general and technical STEM tracks separately. That is, the interventions had no effect on the 20-percentage-point gender gap in the probability of pursuing STEM studies after Grade 10.

Several mechanisms can be posited for this lack of effect on the enrolment status of Grade 10 girls the next year. First, the interventions did not appear to be especially well suited to increase the share of girls enrolling in the STEM technical tracks in Grade 11, where their share is particularly low (17%). As is noted below, the positive effects observed on the STEM enrolment decisions of girls in Grade 12 are concentrated among the high achievers in maths. In Grade 10, high-achieving students are traditionally not directed to the technical tracks. If low-achieving students are less likely to be affected, then it is not surprising to find limited effects on enrolment in STEM technical tracks. Turning to the general science track, female under-representation is only moderate in Grade 11 (in 2016/17, the female share was 47%) and this track is the most common choice (usually the default) for high-performing students, including girls. Unlike the other high school tracks, it gives access to almost all fields of study in higher education and thus does not signal any strong commitment to a STEM education or career in the future; that is, the potential of STEM role models to influence enrolment in this track is limited. Female students who turn away from the science track in high school are unlikely to even consider a STEM career as a viable option, making their choices less easily reversible.²³

²³Consistent with this interpretation, the survey data indicate that among Grade 10 students in the control group, only 24% of the girls who did not enrol in the science track the following year said they could see themselves working in a science-related job, compared to 87% of those who did.

Table 5. *Impact of Role Model Interventions on Grade 10 Students' Enrolment Status the Following Year*

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
All STEM tracks							
Grade 11: Science track	0.355	−0.002 (0.011)	0.862 [0.970]	0.551	−0.006 (0.012)	0.640 [0.720]	0.800
General vs. technical STEM track							
Grade 11: Science - general track	0.328	0.003 (0.010)	0.794 [0.794]	0.416	0.004 (0.011)	0.710 [0.710]	0.925
Grade 11: Science - technical track	0.026	−0.005 (0.004)	0.188 [0.377]	0.135	−0.010 (0.008)	0.234 [0.468]	0.562
Other tracks or repeater							
Grade 11: Other tracks	0.545	0.006 (0.012)	0.614	0.324	0.020 (0.012)	0.110	0.391
Repeater or dropout	0.101	−0.004 (0.009)	0.636	0.126	−0.014* (0.008)	0.090	0.327
N		7,241		6,459			

Notes: This table reports estimates of the treatment effects of classroom interventions on Grade 10 students' enrolment outcomes in the academic year following the classroom interventions, i.e. 2016/17. The enrolment outcomes are measured using student-level administrative data. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). The *q*-values associated with the treatment effect estimates on "Grade 11: Science track" are adjusted for multiple testing across the study's nine main outcomes of interest, separately by gender (see Appendix ?? for details). The *q*-values associated with the treatment effect estimates on enrolment in the general and technical STEM tracks are adjusted for multiple testing across these two tracks, separately by gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Field of study after Grade 12. A central finding of the study is that the role model interventions had significant effects on the educational choices of girls in Grade 12, by raising their probability of enrolling in selective and in male-dominated STEM programs in higher education.²⁴

Table 6 indicates a positive but statistically insignificant ($p = 0.14$) effect of the interventions on female students' probability of enrolling in undergraduate STEM programs, of 2.0 p.p. from a baseline of 28.9%, i.e. a 7% increase. Importantly, however, we find that the classroom visits had larger and statistically significant effects on female students' enrolment in the STEM programs in which they are most severely under-represented. Our estimates show that their probability of enrolling in selective STEM programs increased by 3.1 p.p. (a 28% increase from the baseline of 11.0%, significant at the 1% level). In male-dominated STEM programs (mathematics, physics, computer science, and engineering), their enrolment probability increased by 3.4 p.p. from a baseline of 16.6% (i.e. a 20% increase, significant at the 1% level).

These results are particularly striking given that selective and male-dominated STEM programs are not only the most prestigious tracks but also those where the gender gap is greatest, explaining approximately half of the STEM-related gender pay gap in France (see the discussion in Section 1.2). Our estimates indicate that, on average, the role model interventions induced one girl in every two Grade 12 science-track classes to switch to a selective or a male-dominated STEM program at entry into higher education.²⁵

The more detailed results presented in Appendix Table F6 suggest that these effects are driven by girls switching from non-STEM programs and from STEM programs that are neither selective nor male-dominated. A significant decline in female enrolment is indeed found for non-selective undergraduate programs in earth and life sciences (-2.2 p.p.), while small reductions of 0.2 to 0.9 p.p. are found for selective programs in humanities and non-STEM vocational programs, as well as for non-selective programs in medicine, law and economics, humanities and psychology, and sports studies. Role models thus appear to have affected the enrolment outcomes of Grade 12 girls who would have otherwise chosen a curriculum in a female-dominated environment, be it in STEM or outside STEM.

By contrast, we find no evidence of statistically significant effects of the interventions on the college major decisions of boys in Grade 12. The estimated effect on their probability of enrolling in a STEM undergraduate

²⁴STEM programs are classified as being either male-dominated or female-dominated depending on whether the share of female students in the corresponding field is below or above 50% (see Appendix C.2 for details).

²⁵This calculation is based on an average of 15 girls per class.

Table 6. *Impact of Role Model Interventions on Grade 12 Students' Enrolment Status the Following Year*

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
All undergraduate STEM majors							
Major: STEM	0.289	0.020 (0.014)	0.139 [0.157]	0.470	−0.002 (0.019)	0.925 [0.926]	0.310
Selective vs. non-selective STEM							
Major: selective STEM	0.110	0.031*** (0.011)	0.006 [0.012]	0.232	0.008 (0.015)	0.575 [0.575]	0.200
Major: non-selective STEM	0.178	−0.011 (0.012)	0.333 [0.333]	0.239	−0.010 (0.013)	0.445 [0.575]	0.959
Male- vs. female-dominated STEM							
Major: male-dominated STEM (maths, physics, computer science)	0.166	0.034*** (0.012)	0.004 [0.012]	0.379	0.013 (0.019)	0.485 [0.575]	0.289
Major: female-dominated STEM (earth and life sciences)	0.123	−0.015 (0.011)	0.169 [0.226]	0.091	−0.015 (0.009)	0.119 [0.477]	0.983
Other tracks or dropout							
Other non-STEM programs	0.507	−0.031** (0.016)	0.049	0.293	−0.008 (0.015)	0.571	0.286
Not enrolled in higher education	0.206	0.011 (0.013)	0.430	0.237	0.012 (0.015)	0.425	0.957
N		2,827			2,924		

Notes: This table reports estimates of the treatment effects of classroom interventions on Grade 12 (science track) students' enrolment outcomes in the academic year following the classroom interventions, i.e. 2016/17. The enrolment outcomes are measured using student-level administrative data. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). The *q*-values associated with the treatment effect estimates on "Major: STEM" are adjusted for multiple testing across the study's nine main outcomes of interest, separately by gender (see Appendix ?? for details). The *q*-values associated with the treatment effect estimates on enrolment in the different STEM majors are adjusted for multiple testing across these different majors, separately by gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

program is close to zero (-0.2 p.p. from a baseline of 47.0%), while the effects on enrolment in selective STEM (0.8 p.p. from a baseline of 23.2%) and male-dominated STEM programs (1.3 p.p. from a baseline of 37.9%) are small and insignificant at conventional levels. It should be noted, however, that these estimates do not allow drawing firm conclusions on the impact of the program on the gender gap in STEM enrolment, as we lack the statistical power to reject the null hypothesis of equal effects on male and female students.

Taken together, the results for Grade 12 students indicate that the interventions were effective in steering girls towards the STEM tracks in which they are heavily under-represented, even though two-thirds of the role models came from female-dominated STEM fields (earth and life sciences) and that the interventions were designed to promote all types of STEM careers, including those where women now outnumber men. These findings suggest that in the current setting, the role models affected only the most strongly stereotyped choices.

Academic performance. The effects of the classroom visits on academic performance can be documented for students in Grade 12 based on the *Baccalauréat* exams, taken a few months after the classroom interventions. The estimates of the effect of the treatment on students' performance on the maths test and on the probability of obtaining the *Baccalauréat* are close to zero and statistically insignificant for both genders (see Appendix Table F7).²⁶ Although hypothetically the role models could have strengthened students' motivation to be admitted to the most selective STEM programs, and so increased the time devoted to studying maths and science, we find no evidence of any such effect. We can therefore rule out that the effects on the enrolment outcomes of girls in Grade 12 were driven by increased effort and accordingly better academic performance.

4.4 Robustness Checks

We conducted a series of robustness checks for our main findings (see Appendices G and H).

First, we checked that our results are robust to using a specification that does not control for students' characteristics at baseline. The resulting estimates for the survey-based outcomes (Table G1) are quite similar to those presented in Tables 3 and 4. The estimates without controls are also qualitatively similar to those reported in Tables 5 and 6 for enrolment outcomes (Table G2). They tend to be slightly larger (but not

²⁶The small negative effect on overall *Baccalauréat* performance for female students is only marginally significant when we control for student characteristics and is not robust to omitting these controls.

statistically significant) for boys in Grade 12, which we interpret as a consequence of the small residual imbalances in the male sample.²⁷

Second, we assessed the sensitivity of our results to non-parametric randomization inference tests rather than model-based cluster-robust inference. The tests are performed by comparing our ITT estimates with the distribution of “placebo” ITT estimates obtained by randomly re-assigning treatment 2,000 times among participating classes within each school and grade level. The results yield empirical p -values that are generally close to the model-based p -values (see Table H1). Although they tend to be slightly more conservative, they confirm the interventions’ statistically significant effects on female enrolment in selective and male-dominated undergraduate STEM programs.

5 Information, Persistence, and Spillovers

In this section, we test the sensitivity of students’ attitudes and choices to the informational component of the intervention. We then extend the analysis to the persistence of effects on student perceptions, the timing of the interventions, and the potential spillover effects on enrolment outcomes.

The role of information provision. Role model interventions not only foster self-identification but intrinsically contain an informational component. While our design does not allow fully disentangling these two mechanisms, there is suggestive evidence that the purely informational component of the classroom visits does not in itself explain the changes in female students’ college major decisions after Grade 12.

As described in Section 2, we initially sent a set of slides to the role models to assist them during the intervention. The first six slides highlighted some stylized facts about jobs in science and female underrepresentation in STEM careers, but gave only limited information on employment conditions in such careers, and no information on salaries. Starting on 20 November 2015, we sent six additional slides to 36 of the 56 role models, with more detailed information regarding wage and employment gaps between STEM and

²⁷Balancing tests performed separately by grade level and gender do not point to unusually large covariate imbalance between the treatment and control groups in any of the subsamples (results available upon request). However, the predicted probability of being enrolled in a selective STEM program is marginally higher in the treatment than in the control group for boys in Grade 12 (by 0.8 p.p. from a baseline of 23.8%, significant at the 5% level).

non-STEM jobs, as well as differences between male and female students' choice of studies. The role models were free to integrate these slides into their final presentation or just use them as a support.²⁸

The results reported in Appendix I show that students' characteristics are balanced between the role models who received the standard or the "augmented" set of slides (see Table I1).²⁹ Consistent with the thesis that the effects on college major decisions were not driven primarily by the standardized information contained in the slides, we find that the role models who had just the standard slideshow also had positive and significant effects on female students' probability of enrolling in selective STEM and male-dominated STEM programs after Grade 12 (see Table I2). And we find no evidence that those who had the additional slides had significantly larger effects on girls' STEM enrolment outcomes, although the students with whom they interacted were more likely to agree that science-related jobs pay higher salaries.³⁰

Persistence. The effects on students' perceptions that we observe could be short-lived. We explore this issue by comparing the treatment effects depending on the time elapsed between the classroom visit and the date when the student completed the survey. Splitting the sample at the median of this time interval (63 days), we find that, on average, students below this threshold completed the survey 46 days after the intervention, those above it in 93 days, i.e. an extra 47 days. Note that students whose class was visited early are more likely to have waited longer before completing the survey. The comparison of treatment effects between the two subsamples should therefore be interpreted with some caution when assessing persistence, since these effects may also capture heterogeneity related to the timing of the visits (see next paragraph). Moreover, the interval between the intervention and survey completion never exceeds six months. With these caveats in mind, the results in Appendix Table I3 suggest that the treatment effects did not vanish quickly, insofar as they are statistically significant and of comparable magnitude in both subsamples and, in most cases, are not significantly different. These results should also attenuate concerns about social desirability

²⁸Screenshots of the two sets of slides are shown in Appendix Figures I1 and I2.

²⁹At first, we planned to allocate the two sets of slides randomly to the role models and were able to do so for a subset of 14 participants. However, the L'Oréal Foundation requested that going forward, all remaining role models be provided with the "augmented" version. Those who had already started the visits kept the standard version. To ensure sufficient statistical power, we present results for the entire sample of role models, controlling for month-of-visit fixed effects. The results are qualitatively similar if we restrict the sample to the subset to whom the slides were randomly assigned.

³⁰Note that since the use of the supplementary slides was at the discretion of the role models, the coefficient on the interaction term T^* Additional slides in Appendix Table I2 should be interpreted as a lower bound for the effect of the more information-intensive treatment.

bias, since experimenter demand effects would be expected to be greater for students who took the survey shortly after the intervention.

Timing of visits. We find suggestive evidence that earlier interventions had greater effects on the college choices of Grade 12 students, which could be made through May. For girls, the positive effects on enrolment in STEM, selective STEM, and male-dominated STEM are all statistically significant for the classroom visits that took place in November or December 2015, whereas the effects of visits in January or February 2016 are smaller and not significant (see Appendix Table I4).³¹ With the caveat that we cannot reject the null hypothesis of equal treatment effects across the two sub-periods, these findings suggest that interventions made when many students are still undecided about their field of study and career plans may be more effective than those on the eve of the deadline when irreversible choices may already have been made.

Spillovers. An important issue is whether the interventions could have influenced the educational choices of students in the control group. These students may have heard about the visits directly, through their schoolmates in treatment group classes, or indirectly, through regular social interaction. If the direction of such effects is the same for students in the treatment and control groups, ignoring spillovers would cause us to underestimate the treatment effects.

On the last page of the post-intervention survey questionnaire, the students in the treatment group were asked whether they had discussed the classroom intervention with their classmates, with schoolmates from other classes, or with friends outside of school, as a way of assessing possible spillover effects. Students in the control group received a slightly different version of this final section, asking whether they had heard of classroom visits by male or female scientists in other classes, with no explicit mention of the FGIS program.

The survey evidence suggests that the scope for spillover effects was limited, which is consistent with the idea that in French schools most peer interactions take place within the class (Avvisati *et al.*, 2014). In the treatment group, 58% of Grade 10 students and 63% of Grade 12 students report having talked about the classroom intervention with their classmates, but only 24% and 27% report having talked with schoolmates

³¹We are confident that these differences are not driven primarily by confounding factors. Although the subsamples defined on the basis of whether the visit took place in 2015 or in 2016 exhibit significant imbalances with respect to education districts and the share of private schools, they are reasonably balanced with respect to students' characteristics and predicted STEM enrolment (results available upon request).

from other classes (see Appendix Table J1). In the control group, only 14% of students in Grade 10 report having heard of the classroom visits, almost all of them (12%) only vaguely. In Grade 12, students in the control group are more likely (34%) to report being at least vaguely aware of the visits, but fewer than 5% of boys and girls have a precise recollection. Overall, these summary statistics suggest that spillover effects were quite limited indeed.

We complement this survey evidence with a more formal investigation of whether the interventions affected the higher education choices of Grade 12 students whose classes were not assigned to the treatment group—either classes not selected by principals for the interventions or participating classes randomly assigned to the control group. Our empirical strategy, described in detail in Appendix J, builds on the following intuition: for schools that participated in the evaluation, the random assignment of treatment to participating classes makes it possible to estimate the average outcome that would have resulted if *all* students had only been exposed to the spillover effects of classroom interventions without being *directly* exposed to a role model. This unobserved “spillover-only” counterfactual can be estimated at the school level by computing an appropriately weighted average of the outcomes of students in the non-participating classes and in the participating classes that were assigned to the control group. Students in the control group classes are given a greater weight, as they are used to account for both their own outcome and for the hypothetical outcome in the treatment classes, if they had been exposed to a role model only indirectly.³² The spillover effects of the interventions are then estimated by comparing the “spillover-only” counterfactual and a “no-treatment” counterfactual. This second counterfactual is constructed using non-participating schools, which we observe in the administrative data, whose observable characteristics are similar to those of the participating schools over the period 2012–2015. Having verified that trends in student enrolment outcomes were parallel between the two groups of schools in the pre-treatment period, we implement a difference-in-differences estimator to identify the interventions’ spillover effects on students’ STEM enrolment outcomes at college entry.

³²For instance, in a school with two participating classes, one treated and one control, and one non-participating class, the “spillover-only” counterfactual is computed by assigning a weight of 1 to the non-participating class and a weight of 2 to the control group class (if all classes have the same number of students). By virtue of randomization, mean outcomes in the control classes provide unbiased estimates of the counterfactual “spillover-only” outcomes in the treatment classes.

This difference-in-differences approach produces no evidence of significant spillover effects on non-treated Grade 12 students (see Table J2 in the Appendix). Together with the survey evidence, they suggest that spillovers between treatment and control classes were at most limited.

6 What Makes the Role Model Intervention Effective?

To understand what drives the success of the interventions, we investigate the characteristics of the message, the messenger, and the students who were the most responsive. One advantage of our setting is that we can compare treatment effects for groups of students who were exposed to different role models or who responded differently to the same one.

We proceed in three steps. First, we show that the treatment effects on STEM enrolment outcomes vary substantially along the two most salient dimensions of heterogeneity, namely the role models' background (L'Oréal professionals vs. researchers) and the students' academic performance. Second, we determine which of the student perceptions were most strongly affected by the role models who had the greatest impact on enrolment outcomes. Third, we build on the machine learning approach of Chernozhukov *et al.* (2018) to analyse whether the students who were particularly receptive or unreceptive to some of the messages conveyed are the same ones whose choice of study was most or least affected by the interventions. We use this approach to determine which messages were most effective.

6.1 Heterogeneous Treatment Effects on STEM Enrolment

We start by investigating how the treatment effects on STEM enrolment vary with the role models' background and the students' performance in maths. Our analysis focuses on Grade 12 students, as we find no evidence of significant effects on enrolment outcomes for Grade 10 students.³³

Role model background: researchers vs. professionals. We find clear evidence that the two types of role model had different effects on the STEM enrolment outcomes of girls in Grade 12 (see Panel A of Table 7 and Appendix Figure K1). The professionals increased female students' probability of enrolling in

³³The results of the heterogeneity analysis by role model background and maths performance for Grade 10 students are reported in Appendix Tables K1 and K2.

a selective STEM program by a significant 5.4 p.p., whereas the researchers had no discernable effect.³⁴ The contrast is qualitatively similar whether male-dominated STEM programs or all STEM programs are considered. While the estimates also point to larger effects for boys who were exposed to role models with a professional background, they are not statistically significant at conventional levels.

Why weren't the two types of role model equally able to steer female students towards STEM fields? The academic role models are, on average, younger than the professionals employed by the sponsoring firm (see Table 2), which might foster greater identification on the part of the students. But because they work in highly specialized fields and in very competitive environments, it is not clear how attainable students might think their achievements are. On the other hand, the professionals tend to have higher pay and more experience, and they come less often from a purely academic background. Also, unlike Ph.D. candidates and postdocs, they hold permanent jobs and their work environment could be perceived as more attractive. Finally, the types of role model might differ in their communication skills and charisma.³⁵ While it is hard to pinpoint the precise attributes that could explain why the professionals had more impact than the researchers, our data allow us to investigate the messages they conveyed more effectively to the students (see Section 6.2).

High vs. low achievers in maths. Academic performance in mathematics is the single most important admission criterion of selective undergraduate STEM programs. Using Grade 12 students' national percentile rank on the *Baccalauréat* maths test to proxy for academic performance, we find that the interventions' positive impact on selective STEM enrolment is driven by female students above the median (see Panel A of Table 8).³⁶ For these girls, the probability of enrolling in a selective STEM program after high school increases by 6.5 p.p. (significant at the 1% level), which corresponds to a 34% increase from the baseline of 19%, while the effect is close to zero for girls below the median and is not statistically significant for boys.

³⁴The difference between the treatment effects of the two types of role model is significant at the 5% level.

³⁵Although we cannot rule this explanation out, we do not think it is the most likely, both because researchers and professionals received a one-day training before visiting the high schools and because the Ph.D. candidates and postdocs, with their experience as teaching assistants, are probably more used to speaking to a student audience and handling classrooms. It is also possible that the professionals were more motivated than the researchers because they volunteered for the program. Our feeling is that this aspect may not have played a major role. We met the academic role models on multiple occasions and our general impression is that they were genuinely enthusiastic about their participation.

³⁶As noted in Section 4.3, we find no significant impact of the interventions on students' performance on the maths test of the *Baccalauréat* exam, which mitigates concerns about potential endogenous selection bias when conditioning on this variable.

Table 7. *Heterogeneous Treatment Effects on Grade 12 Students' Outcomes, by Role Model Background*

	Girls			Boys		
	Role model background			Role model background		
	Resear- chers (1)	Profes- sionals (2)	<i>p</i> -value of diff. [<i>q</i> -value] (3)	Resear- chers (4)	Profes- sionals (5)	<i>p</i> -value of diff. [<i>q</i> -value] (6)
Panel A. Enrolment outcomes						
Undergraduate major: STEM	-0.014 (0.024)	0.043*** (0.016)	0.049 [0.146]	-0.017 (0.030)	0.010 (0.024)	0.480 [0.729]
Undergraduate major: selective STEM	-0.002 (0.019)	0.054*** (0.013)	0.017 [0.034]	-0.016 (0.024)	0.028 (0.019)	0.151 [0.303]
Undergraduate major: male-dominated STEM	0.015 (0.019)	0.046*** (0.015)	0.188 [0.189]	-0.008 (0.028)	0.029 (0.026)	0.340 [0.340]
N	1,180	1,647		1,312	1,612	
Panel B. Student perceptions						
Positive perceptions of science-related careers (index)	0.166*** (0.049)	0.380*** (0.039)	0.001 [0.003]	0.157*** (0.046)	0.181*** (0.046)	0.711 [0.800]
More men in science-related jobs	0.137*** (0.025)	0.113*** (0.021)	0.461 [0.649]	0.161*** (0.023)	0.139*** (0.021)	0.486 [0.729]
Equal gender aptitude for maths (index)	0.095** (0.046)	0.068** (0.033)	0.623 [0.702]	0.185*** (0.067)	0.078 (0.053)	0.208 [0.729]
Women don't really like science	0.039*** (0.015)	0.044*** (0.012)	0.815 [0.816]	0.091*** (0.025)	0.060*** (0.017)	0.284 [0.729]
W face discrimination in science-related jobs	0.124*** (0.035)	0.061*** (0.024)	0.135 [0.243]	0.088*** (0.028)	0.064*** (0.023)	0.509 [0.729]
Taste for science subjects (index)	-0.054 (0.049)	0.065 (0.044)	0.074 [0.167]	-0.011 (0.056)	0.033 (0.055)	0.567 [0.729]
Self-concept in maths (index)	0.081 (0.059)	0.032 (0.043)	0.504 [0.649]	0.126** (0.050)	0.023 (0.043)	0.118 [0.729]
Science-related career aspirations (index)	-0.089 (0.057)	0.231*** (0.044)	0.000 [0.001]	0.060 (0.054)	0.074 (0.047)	0.846 [0.847]
N	1,067	1,533		1,174	1,462	

Notes: This table reports estimates of the treatment effects of the role model interventions on the outcomes of Grade 12 students, separately by gender and by background of the female role model who visited the classroom (professional or researcher). Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 2 (for girls) and columns 4 and 5 (for boys) report the local average treatment effect (LATE) estimates for students whose class was visited by a researcher or a professional, respectively. They are obtained from a regression of the outcome of interest on the interaction between a classroom visit indicator and indicators for the role model being either a researcher or a professional, using treatment assignment (interacted with the role model background indicator) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report both the cluster-robust model-based *p*-value for the difference between the treatment effects estimates for students visited by a professional vs. a researcher and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. *Heterogeneous Treatment Effects on Grade 12 Students' Outcomes, by Maths Performance*

	Girls			Boys		
	Performance in maths			Performance in maths		
	Below median (1)	Above median (2)	<i>p</i> -value of diff. [<i>q</i> -value] (3)	Below median (4)	Above median (5)	<i>p</i> -value of diff. [<i>q</i> -value] (6)
Panel A. Enrolment outcomes						
Undergraduate major: STEM	0.007 (0.021)	0.028 (0.026)	0.567 [0.639]	-0.036 (0.027)	0.012 (0.029)	0.241 [0.484]
Undergraduate major: selective STEM	-0.004 (0.013)	0.065*** (0.022)	0.011 [0.022]	-0.019 (0.019)	0.023 (0.026)	0.232 [0.464]
Undergraduate major: male-dominated STEM	0.020 (0.018)	0.042* (0.023)	0.506 [0.507]	-0.001 (0.026)	0.016 (0.028)	0.672 [0.673]
N	1,544	1,211		1,497	1,328	
Panel B. Student perceptions						
Positive perceptions of science-related careers (index)	0.239*** (0.053)	0.340*** (0.058)	0.263 [0.440]	0.053 (0.056)	0.275*** (0.052)	0.011 [0.100]
More men in science-related jobs	0.152*** (0.026)	0.078*** (0.024)	0.056 [0.339]	0.159*** (0.025)	0.143*** (0.019)	0.609 [0.822]
Equal gender aptitude for maths (index)	0.034 (0.043)	0.134*** (0.045)	0.151 [0.339]	0.055 (0.063)	0.212*** (0.062)	0.083 [0.375]
Women don't really like science	0.023 (0.015)	0.061*** (0.016)	0.130 [0.339]	0.077*** (0.025)	0.072*** (0.022)	0.874 [0.874]
W face discrimination in science-related jobs	0.096*** (0.027)	0.088*** (0.031)	0.845 [0.845]	0.097*** (0.031)	0.047 (0.028)	0.268 [0.484]
Taste for science subjects (index)	-0.049 (0.051)	0.040 (0.056)	0.293 [0.440]	-0.007 (0.063)	0.031 (0.053)	0.658 [0.822]
Self-concept in maths (index)	0.063 (0.049)	-0.045 (0.051)	0.145 [0.339]	0.092* (0.048)	0.019 (0.041)	0.249 [0.484]
Science-related career aspirations (index)	0.064 (0.049)	0.134** (0.060)	0.397 [0.511]	0.042 (0.056)	0.071 (0.053)	0.730 [0.822]
N	1,420	1,123		1,340	1,227	

Notes: This table reports estimates of the treatment effects of the role model interventions on Grade 12 students' outcomes, separately by gender and performance in maths. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Students' performance in maths is measured from the grades obtained on the final maths exam of the *Baccalauréat*. Columns 1 and 2 (for girls) and columns 4 and 5 (for boys) report the local average treatment effect (LATE) estimates for students below and above the median level of performance in maths, respectively. They are obtained from a regression of the outcome of interest on the interaction between a classroom visit indicator and indicators for the student being below or above the median level of performance in maths, using treatment assignment (interacted with the maths performance dummies) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report both the cluster-robust model-based *p*-value for the difference between the treatment effects estimates for students above vs. below the median performance in maths and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini *et al.* (2006) and described in Anderson (2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The differences in treatment effects between high- and low-achieving girls in maths are qualitatively similar for enrolment in male-dominated STEM programs and for all STEM programs.³⁷

Potential confounders. Even though the role models were not randomly assigned to the participating schools, the classroom visits of the researchers and the professionals are similarly distributed over the period of intervention (see Appendix Table E9, Panel A).³⁸ The characteristics of the schools and students visited by the two sets of role models also appear to be reasonably balanced (see Appendix Tables E7 and E8). There are, however, a few statistically significant differences. In Grade 12, in particular, the professionals were more likely than the researchers to visit private high schools (24% vs. 10%).

Despite these small imbalances, Table 9 shows that the significantly larger impact of professionals on selective STEM enrolment for Grade 12 girls is robust to controlling for a full set of interactions between the treatment group dummy and the observable characteristics of students and schools (columns 1 and 2), as well as for interactions between the treatment dummy and the role models' characteristics and the month of intervention (column 3). That is, there is no indication that the heterogeneous treatment effects according to the role models' background are confounded by differential selection into schools or by other observable characteristics of the role models.³⁹ Table 9 further shows that the larger treatment effects for high-achieving girls in maths are robust to controlling for the same set of interactions.⁴⁰

6.2 Heterogeneous Effects on Student Perceptions

Role model background: researchers vs. professionals. Why were the professionals more effective than the researchers in influencing female students' choice of study? To investigate this question, we examine how the two groups managed to change students' perceptions. We consider as potential channels of influence

³⁷Appendix Figure K2 further shows that the effects on STEM enrolment are mainly driven by girls in the top quartile of maths performance.

³⁸The average interval between the visits and the date when students completed the survey is also comparable between the two groups of role models (Table E9, Panel B).

³⁹The significantly larger impact of professionals on Grade 12 girls' probability of enrolling in STEM programs in general is also robust to controlling for these interactions (results available upon request).

⁴⁰We also explored whether the effects of the interventions could be mediated by the subsequent interactions between the students and the teacher who was present during the visit. For instance, science teachers might be inclined to reiterate the role model's messages about science-related careers while female teachers might amplify the effects of the interventions for female students. Using data from the role model survey, we find no support for these hypotheses (results available upon request): the treatment effects on the STEM enrolment outcomes of girls in Grade 12 do not vary significantly according to the teacher's gender or subject taught.

Table 9. *Treatment Effects (ITT) on Enrolment in a Selective STEM Program for Grade 12 Students: Heterogeneity by Student and Role Model Characteristics*

	Dependent variable: enrolled in a selective STEM program					
	Girls			Boys		
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Treatment group indicator (T) interacted with student characteristics</i>						
T*Bac percentile rank in maths (/100, demeaned)	0.138*** (0.048)	0.153*** (0.055)	0.155*** (0.054)	0.060 (0.055)	0.015 (0.057)	0.013 (0.059)
T*Bac percentile rank in French (/100, demeaned)		-0.036 (0.043)	-0.030 (0.043)		0.083 (0.056)	0.082 (0.056)
T*High SES, demeaned		0.032 (0.026)	0.026 (0.027)		-0.013 (0.031)	-0.018 (0.031)
<i>Treatment group indicator (T) interacted with role model characteristics</i>						
T*Professional	0.059*** (0.020)	0.066*** (0.020)	0.102*** (0.025)	0.055** (0.027)	0.048* (0.028)	0.070* (0.036)
T*Participated in the program the year before			-0.047** (0.023)			0.024 (0.042)
T*Age (demeaned)			0.001 (0.001)			-0.000 (0.002)
T*Non-French			-0.022 (0.026)			-0.006 (0.050)
T*Has children			0.029 (0.026)			0.034 (0.035)
T*Has a Ph.D. degree			0.091*** (0.023)			0.057 (0.039)
T*Field: maths, physics, engineering			-0.040* (0.024)			-0.035 (0.030)
<i>Other controls</i>						
Treatment group indicator (T)	Yes	Yes	Yes	Yes	Yes	Yes
Student characteristics	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
T interacted with school characteristics	No	Yes	Yes	No	Yes	Yes
T interacted with month of intervention	No	No	Yes	No	No	Yes
Observations	2,827	2,827	2,827	2,924	2,924	2,924
Adjusted R-squared	0.125	0.125	0.127	0.196	0.195	0.194

Notes: Each column corresponds to a separate regression. The sample is restricted to students in Grade 12 (science track). The outcome variable is an indicator for being enrolled in a selective STEM undergraduate program in the year following high school graduation, i.e. 2016/17. The models are estimated separately for girls (columns 1–3) and boys (columns 4–6). The coefficients reported in columns 1 and 4 are from a regression of the outcome variable on a treatment group indicator (*T*), student characteristics, school fixed effects, and the treatment group indicator interacted with the student's *Baccalauréat* percentile rank in maths (between 0 and 1) and with an indicator for the role model being a professional. The specification in columns 2 and 5 includes further interactions between the treatment group indicator and both student and school characteristics. Finally, the specification in columns 3 and 6 adds interactions between the treatment group indicator and the characteristics of role models as well as interactions between the treatment group indicator and dummies for the month of intervention. The student characteristics are those listed in Table 1 as well as the student's percentile ranks on the *Baccalauréat* final exams in maths and French. The role model characteristics consist of age and a set of indicators for being a professional, having participated in the program the year before, being non-French, having children, holding a Ph.D. degree, and having graduated from a male-dominated STEM field (maths, physics, engineering). The school characteristics are dummies for the regional education authority where the high school is located (Paris, Créteil and Versailles) and a dummy for whether the school is private. School characteristics are only included through their interactions with the treatment group indicator, as these characteristics are absorbed by the school fixed effects. Since each high school was visited by at most one role model, role model and month-of-visit fixed effects are also absorbed by the school fixed effects. Standard errors (in parentheses) are adjusted for clustering at the class level. Observations with some missing characteristics are included in the regressions. An arbitrary value is assigned to all the missing characteristics and a set of dummy variables is created, with each variable being equal to one if the corresponding information is missing. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the dimensions studied in Section 4, namely general perceptions of science-related careers and gender roles in science, taste for science subjects, self-concept in maths, and science-related career aspirations.

For girls in Grade 12, a key finding is that professionals and researchers were equally successful in debunking stereotypes on gender differences in maths aptitude, and that they reinforced students' perceptions that "women don't really like science" and that "women face discrimination in science-related jobs" to a comparable extent (Table 7, Panel B).⁴¹ These results suggest that the "gender debiasing" component of the classroom interventions, which emphasized men's and women's equal predisposition for science, cannot explain, alone, why the interventions increased girls' enrolment in selective STEM; otherwise the two groups of role models would be expected to have had the same effect on enrolment outcomes, which is not what we find. By contrast, Table 7 reveals that in Grade 12, the professionals improved female students' perceptions of science-related jobs more than the researchers and stimulated their aspirations for such careers more strongly. These dimensions thus seem more likely to explain why the professionals had a stronger influence on female students' choice of study.⁴²

High vs. low achievers in maths. The differences in the effects on students' perceptions are less pronounced between girls above and below the median of maths performance in Grade 12 (Table 8, Panel B). Although the differences are not statistically significant, it is interesting to note that high-achieving girls seem to have been more receptive to the messages that the professionals were better at conveying. Indeed, the point estimates suggest that perceptions of science-related careers improved more among the girls with above-median performance in maths. Aspirations for science-related careers also increased more among these girls, whereas awareness of female under-representation in science-related jobs increased less.

6.3 A Generalization Using Machine Learning Techniques

Investigating treatment effect heterogeneity by splitting the sample into subgroups inevitably entails the risk of data mining. To address this concern, we carry out a systematic exploration of heterogeneous treatment

⁴¹The results for girls and boys in Grade 10 are presented in Appendix Table K1. In this grade level, the effects of the two types of role model on girls' perceptions are more similar and are not significantly different after adjusting for multiple hypotheses testing.

⁴²The results for boys in Grade 10 (Appendix Table K1, columns 4 to 6) and Grade 12 (Table 7, columns 4 to 6) do not show substantial differences in effects. If anything, the professionals seem to have been slightly more effective than the researchers in increasing Grade 10 boys' taste for science and debunking their stereotyped views on gender differences in maths aptitude.

effects using machine learning (ML) methods (see Athey and Imbens, 2017, for a review). Specifically, we adopt the approach developed by Chernozhukov *et al.* (2018) to estimate conditional average treatment effects (CATE). A detailed description can be found in Appendix L. Essentially, this approach allows us to compare the characteristics of the students whose educational choices were the most and the least affected by the classroom interventions. This first step serves to confirm, in a more agnostic way, the insights obtained from the comparison between professionals and researchers and between high and low achievers in maths. Building on Chernozhukov *et al.* (2018), we then use a novel method to estimate the correlation between the treatment effects on enrolment outcomes and the effects on student perceptions. This second step takes advantage of the predicted heterogeneity in treatment effects by student and role model characteristics to identify the messages that had the greatest impact on students' educational choices.

Heterogeneous treatment effects on enrolment outcomes. The results from the estimation of heterogeneous treatment effects on enrolment outcomes after Grade 12 are reported in Appendix Tables L1 and L2 and are described in detail in Appendix L. The ML approach of Chernozhukov *et al.* (2018) confirms that there is considerable heterogeneity in treatment effects on selective STEM enrolment among girls in Grade 12: they range from a small negative impact for the least affected quintile of girls to a large and significant 13.9 percentage-point increase for the most affected quintile.⁴³ Consistent with the results discussed in Section 6.1, the comparison of the characteristics of the most and least affected quintiles confirms that role model background and student maths performance are the two main observable dimensions of heterogeneity: the average gap in maths performance rank between girls in the top and bottom quintiles of predicted treatment effects on selective STEM enrolment is as much as 63 percentiles, and the difference in the probability that the class was visited by a professional is 14.8 percentage points.

Heterogeneous treatment effects on potential channels. The results for heterogeneous treatment effects on student perceptions are reported in Appendix Table L3. For each possible channel, we compare the average maths performance of Grade 12 girls in the top and bottom quintiles of predicted treatment effects, as well as their probability of being exposed to a professional rather than a researcher. The results confirm

⁴³The lesser heterogeneity in the effects on enrolment in male-dominated STEM is also confirmed, with no statistically significant difference between the top and bottom quintiles of predicted treatment effects.

that the role models with a professional background conveyed a positive image of science and raised girls' aspirations for science careers significantly more than the researchers. The ML approach also shows that the professionals were significantly less likely than the researchers to increase Grade 12 girls' awareness of the under-representation of women in science-related jobs: compared to the least affected quintile of girls for this outcome, the most affected quintile are 11.2 percentage points more likely to have been visited by a researcher. These results are consistent with the notion that gender-neutral messages about careers in science are more effective than gender-related messages in steering girls towards STEM.

Regarding maths performance, the ML approach broadly confirms the insights from the subgroup comparisons presented in Section 6.2, but it appears better suited to reveal significant contrasts. Average maths performance is found to be significantly better among the girls whose perceptions of science-related careers and taste for science subjects improved the most. Conversely, maths performance is significantly poorer among those whose awareness of female under-representation in STEM and perception of gender discrimination increased the most.

Correlation between treatment effects. So far, our discussion of the channels of influence has sought to identify the main dimensions of treatment effect heterogeneity on STEM enrolment outcomes and has investigated how the effects on student perceptions vary along these dimensions. We now present results from a more general approach that builds on Chernozhukov *et al.* (2018) to produce a direct estimate of the correlation between the treatment effects on different outcomes conditional on exogenous observable characteristics. This approach, whose details are provided in Appendix L.3, constitutes a methodological contribution that can be used in other randomized controlled trials to relate treatment effects on different outcomes. In our context, the method allows us to determine whether, given their observable characteristics, the students with the largest treatment effects for a potential channel of influence Y^A are the same as the ones who exhibit the largest treatment effects on enrolment outcome Y^B .

We use this approach to estimate the correlation between the treatment effects for girls in Grade 12 (see Appendix Table L5). The results confirm that some channels are more important than others in steering female students towards STEM studies. In particular, we find that the treatment effects on girls' enrolment in selective STEM exhibit a strong and significant positive correlation with the improvement in their perceptions

of science-related careers ($\hat{\rho} = 0.96$) and a weaker positive correlation with their increased aspirations for such careers ($\hat{\rho} = 0.36$). By contrast, debiasing girls' attitudes towards gender differences in maths aptitude is not strongly associated with increased enrolment in selective STEM programs ($\hat{\rho} = 0.19$) and, if anything, reinforcing the belief that women suffer discrimination in science careers tends to deter girls from enrolling in these programs ($\hat{\rho} = -0.34$).

Overall, the results based on the correlations between treatment effects are consistent with and extend those obtained earlier. They suggest that the most effective role models were those who managed to convey a positive image of science careers and raise students' aspirations without stressing women's under-representation and its possible causes too strongly. These features are in line with the main mechanisms usually considered necessary for role models to work: generating a sense of fit while moderating the effects of stereotype threat.

7 Conclusion

Based on a large-scale randomized field experiment involving 56 female role models and nearly 20,000 Grade 10 and Grade 12 students, this paper shows that a one-hour in-class exposure to a woman scientist can improve students' perceptions of science careers and significantly increase female participation in STEM fields of study at college enrolment. Remarkably, the positive enrolment effects are observed only in the academic tracks with the most severe gender imbalance, which are the most prestigious and selective, and those that are most maths-intensive. These effects can be expected to increase the future earnings of the target population, since the selective and male-dominated STEM programs offer large wage premiums relative to other programs.

We analyse the channels that could explain these significant effects on enrolment outcomes. We show that the classroom interventions had no discernable effect on students' academic performance and improved their self-concept in maths only slightly, ruling these factors out as primary causes. By contrast, the visits significantly challenged students' stereotyped views of science careers and gender differences in aptitude for science. These effects, however, are observed for both genders in both grades, suggesting that by themselves they cannot explain why the role model interventions affected only the educational choices of girls in Grade 12. Rather, our results offer substantial evidence that female students' response to the role model interventions was mediated by their ability to identify with the female scientists to whom they were exposed. Girls in

Grade 12 were more receptive than the other groups of students to the appealing image of science-related careers embodied by the role models, and their aspirations for such careers increased substantially. This process of identification was less likely to occur among Grade 10 girls, who are further away from career choices, and for boys at both grade levels, who may have found it more difficult to identify with women scientists.

A central finding is that the effects on Grade 12 girls' educational choices varied markedly with the scientists who conducted the classroom visits. This significant heterogeneity demonstrates that role model interventions are not reducible to information provision and highlights the importance of the role models' profile in generating a sense of fit among students. In our experiment, women with a professional background were more effective than researchers in conveying an attractive image of careers in science and elevating girls' aspirations. Our results thus suggest that these are critical skills to target when choosing role models (teachers, instructors, career women, etc.). While our ability to pinpoint the attributes that were to the advantage of the professionals in our setting is limited, a likely explanation is that they were better established in their careers and had better paying jobs than the researchers. The role played by these channels would be a fruitful topic for future research.

Another important insight from the study is that by heightening awareness of the under-representation of women in STEM, while at the same time observing that men and women have equal aptitude for science, the interventions may have unintentionally reinforced students' beliefs that women dislike science and face discrimination in STEM careers. That is, there is suggestive evidence that overemphasizing gender can be counter-productive and that gender-neutral messages might be more effective in steering girls towards STEM fields. In our setting, the role models who reinforced the perception that women are under-represented and discriminated against in science had the least effect on selective STEM enrolment for female students in Grade 12, whereas those who improved girls' perceptions of science careers the most had the greatest impact. These findings suggest that role model interventions need to be carefully designed to limit the potential discouragement effect of overemphasis on gender imbalances.

More generally, our heterogeneity analysis warns against the temptation to view role models as a one-size-fits-all remedy for women's under-representation in STEM fields. We find that the role model effects on

enrolment outcomes are concentrated among high-achieving girls in maths. The effectiveness of this type of intervention in increasing female participation in STEM among lower-performing students remains an open question that warrants further research.

Acknowledgments

We are grateful to the staff at the L'Oréal Foundation, especially Diane Baras, Aude Desanges, Margaret Johnston-Clarke, Salima Maloufi-Talhi, David McDonald, and Elisa Simonpietri for their continued support to this project. We also thank the staff at the French Ministry of Education (Ministère de l'Éducation Nationale, Direction de l'Évaluation, de la Prospective et de la Performance) and at the Rectorats of Créteil, Paris, and Versailles for their invaluable assistance in collecting the data. This paper greatly benefited from discussions and helpful comments from Marcella Alsan, Iris Bohnet, Scott Carrell, Clément de Chaisemartin, Bruno Crépon, Esther Duflo, Lena Edlund, Ruth Fortmann, Pauline Givord, Laurent Gobillon, Marc Gurgand, Élise Huillery, Philip Ketz, Sandra McNally, Amanda Pallais, and Liam Wren-Lewis. We thank participants at the ASSA/AEA Annual Meeting in Atlanta, CEPR/IZA Annual Symposium in Labor Economics 2018 in Paris, EALE 2018 in Lyon, EEA-ESEM 2018 in Cologne, Gender Economics Workshop 2018 in Berlin, Gender and Tech Conference at Harvard, IWAEE Conference in Catanzaro, and Journées LAGV 2018 in Aix-Marseille. We also thank seminar participants at Bristol, DEPP, LSE, Harvard Kennedy School, HEC Lausanne, Maastricht SBE, OECD EDU Forum, PSE, Stockholm University SOFI, and Université Paris 8. We are grateful to the Institut des politiques publiques (IPP) for continuous support and to Sophie Cottet for her assistance in contacting schools. Financial support for this study was received from the Fondation L'Oréal, from the Institut des Politiques Publiques, and from the EUR grant ANR-17-EURE-0001. The project received IRB approval at J-PAL Europe and was registered in the AEA RCT Registry with ID AEARCTR-0000903.

Affiliations

¹CNRS, Paris School of Economics, 48 boulevard Jourdan, 75014, Paris, France

²IREDU-Université de Bourgogne, Esplanade Erasme, 21000 Dijon, France

³University of Toronto, 150 St. George Street, Toronto, Ontario M5S3G7, Canada

References

- Anderson, M.L. (2008). ‘Multiple inference and gender differences in the effects of early intervention: A reevaluation of the abecedarian, perry preschool, and early training projects’, *Journal of the American Statistical Association*, vol. 103(484).
- Athey, S. and Imbens, G.W. (2017). ‘The econometrics of randomized experiments’, in (E. Duflo and A. V. Banerjee, eds.), *Handbook of Economic Field Experiments*, pp. 73–140, vol. 1, Elsevier.
- Avvisati, F., Gurgand, M., Guyon, N. and Maurin, É. (2014). ‘Getting parents involved: A field experiment in deprived schools’, *Review of Economic Studies*, vol. 81(1), pp. 57–83.
- Beaman, L., Duflo, E., Pande, R. and Topalova, P. (2012). ‘Female leadership raises aspirations and educational attainment for girls: A policy experiment in india’, *Science*, vol. 335(6068), pp. 582–586.
- Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B. and Doms, M. (2011). ‘Women in stem: A gender gap to innovation’, U.S. Department of Commerce, Economics and Statistics Administration, Issue Brief No. 04-11.
- Benjamini, Y., Krieger, A.M. and Yekutieli, D. (2006). ‘Adaptive linear step-up procedures that control the false discovery rate’, *Biometrika*, vol. 93(3), pp. 491–507.
- Bettinger, E.P. and Long, B.T. (2005). ‘Do faculty serve as role models? the impact of instructor gender on female students’, *American Economic Review*, vol. 95(2), pp. 152–157.
- Black, D.A., Haviland, A.M., Sanders, S.G. and Taylor, L.J. (2008). ‘Gender wage disparities among the highly educated’, *Journal of Human Resources*, vol. 43(3), pp. 630–650.
- Blau, F.D. and Kahn, L.M. (2017). ‘The gender wage gap: Extent, trends, and explanations’, *Journal of Economic Literature*, vol. 55(3), pp. 789–865.
- Brown, C. and Corcoran, M. (1997). ‘Sex-based differences in school content and the male-female wage gap’, *Journal of Labor Economics*, vol. 15(3), pp. 431–465.
- Bursztyn, L. and Yang, D.Y. (2022). ‘Misperceptions about others’, *Annual Review of Economics*, vol. 14(1), pp. 425–452.
- Canaan, S. and Mouganie, P. (2021). ‘The impact of advisor gender on female students’ stem enrollment and persistence’, *Journal of Human Resources*, vol. 0320-10796R2.
- Carlana, M. (2019). ‘Implicit stereotypes: Evidence from teachers’ gender bias’, *Quarterly Journal of Economics*, vol. 134(3), pp. 1163–1224.
- Carrell, S.E., Page, M.E. and West, J.E. (2010). ‘Sex and science: How professor gender perpetuates the gender gap’, *Quarterly Journal of Economics*, vol. 125(3), pp. 1101–1144.
- Chernozhukov, V., Demirer, M., Duflo, E. and Fernández-Val, I. (2018). ‘Generic machine learning inference on heterogenous treatment effects in randomized experiments’, NBER Working Paper No. 24678.
- Coffman, K.B. (2014). ‘Evidence on self-stereotyping and the contribution of ideas’, *Quarterly Journal of Economics*, vol. 129(4), pp. 1625–1660.
- Del Carpio, L. and Guadalupe, M. (2021). ‘More women in tech? evidence from a field experiment addressing social identity’, *Management Science*, vol. 68(5), pp. 3196–3218.
- Goldin, C. (2014). ‘A grand gender convergence: Its last chapter’, *American Economic Review*, vol. 104(4), pp. 1091–1119.
- Hoogendoorn, S., Oosterbeek, H. and van Praag, M. (2013). ‘The impact of gender diversity on the performance of business teams: Evidence from a field experiment’, *Management Science*, vol. 59(7), pp. 1514–1528.
- Lavy, V. and Sand, E. (2018). ‘On the origins of gender gaps in human capital: Short- and long-term consequences of teachers’ biases’, *Journal of Public Economics*, vol. 167(C), pp. 263–269.
- Lemaire, S. (2012). ‘Les bacheliers s: des poursuites d’études de plus en plus dispersées’, Note d’Information 12.10, MESR-SIES.

- Lim, J. and Meer, J. (2017). ‘The impact of teacher-student gender matches: Random assignment evidence from south korea’, *Journal of Human Resources*, vol. 52(4), pp. 979–997.
- National Science Foundation (2017). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*, National Science Foundation and National Center for Science and Engineering Statistics, special Report NSF 17-310. Arlington, VA.
- Nguyen, T. (2008). ‘Information, role models and perceived returns to education: Experimental evidence from madagascar’, Manuscript.
- Porter, C. and Serra, D. (2020). ‘Gender differences in the choice of major: The importance of female role models’, *American Economic Journal: Applied Economics*, vol. 12(3), pp. 226–254.
- Riise, J., Willage, B. and Alexander, W. (2022). ‘Can female doctors cure the gender stemm gap? evidence from randomly assigned general practitioners’, *The Review of Economics and Statistics*, vol. 104(4), pp. 621–635.
- Terrier, C. (2020). ‘Boys lag behind: How teachers’ gender biases affect student achievement’, *Economics of Education Review*, vol. 77.
- Weinberger, C.J. (1999). ‘Mathematical college majors and the gender gap in wages’, *Industrial Relations*, vol. 38(3), pp. 407–413.

(For Online Publication)

Appendix to

How Effective are Female Role Models in Steering Girls towards STEM? Evidence from French High Schools

Thomas Breda

Julien Grenet

Marion Monnet

Clémentine Van Effenterre

The Economic Journal

December 2022

List of Appendices

A Gender Pay Gap Among College Graduates in France	A-2
B Program Details	A-8
C Student-Level Administrative Data	A-10
D Construction of Synthetic Indices and Multiple Hypotheses Testing	A-12
E Summary Statistics and Balancing Tests	A-14
F Effects of Role Model Interventions: Additional Results	A-22
G Robustness Checks	A-29
H Randomization Inference	A-31
I Information, Persistence, Timing: Additional Results	A-33
J Spillover Effects	A-38
K Heterogeneous Treatment Effects: Subgroup Analysis	A-48
L Heterogeneous Treatment Effects: Machine Learning Methods	A-51
Appendix References	A-67

A Gender Pay Gap Among College Graduates in France

This appendix provides descriptive evidence on the entry-level gender pay gap among French college graduates holding a master’s degree and analyses the contribution of gender segregation in college majors to this gap. The objective of this analysis is to better understand whether the effects of the role model interventions on female students’ choice of study can be expected to reduce the gender pay gap. Section A.1 describes the data sources, while Section A.2 discusses the empirical results.

A.1 Data

Unfortunately, we cannot rely exclusively on administrative data to provide empirical evidence on the gender pay gap by field of study in France, as it is currently not possible to link administrative data on students enrolled in higher education with administrative data on wages and income tax returns. Instead, our analysis is based on the combination of aggregate statistics on student enrolment by college major and gender with survey information on the starting wages of recent cohorts of college graduates.

Data sources. In France, gender segregation and gender pay gaps by college major can be analysed for the population of college graduates who obtained their master’s degree (or equivalent) in 2015 or 2016. For this purpose, we combine several administrative and survey data sources.

SISE Résultats 2015. This individual-level administrative dataset covers all students enrolled in public universities during the academic year 2015/16 (MESRI-DGESIP/DGRI-SIES, 2017) and provides detailed information on each student’s degree program and field of study.

Enquête d’Insertion Professionnelle à 30 Mois des Diplômés de Master 2015 (EIPDM). This survey was conducted in December 2017 by the Ministry of Higher Education (MESRI, 2018) to collect information on the transition of master’s graduates to the labour market. The survey was targeted at students who obtained their master’s degree in 2015 and who entered the labour market within one year after graduation, with an overall response rate of 70%. As part of this survey, master’s graduates were asked to report their annual earnings 18 months after graduation. Our analyses are based on the survey’s public use files, which provide aggregate statistics by gender and college major.^{A.1}

Enquête sur l’Insertion des Diplômés des Grandes Écoles 2018 (EIDGE). This survey was conducted in 2018 by the Conférence des Grandes Écoles (CGE, 2018), a not-for-profit association representing French elite graduate schools. The *Grandes Écoles*, which award a diploma equivalent to a master’s degree, recruit their students through highly competitive national exams taking place at the end of two-year undergraduate selective STEM and non-STEM preparatory courses (*Classes Préparatoires aux Grandes Écoles* or CPGE). The survey was targeted at students who graduated between 2015 and 2017 from one of the 184 *Grandes Écoles* that were members of the CGE in 2018, with an overall response rate of 48%. Our analyses are based on the aggregate statistics published by the CGE separately by gender and by type of *Grande École* (i.e. engineering schools, business schools, and other schools).^{A.2} We only consider students who graduated from a *Grande École* in 2016, since annual earnings 24 months after graduation are only available for this cohort.

^{A.1}https://data.enseignementsup-recherche.gouv.fr/explore/dataset/fr-esr-insertion_professionnelle-master_donnees_nationales/information/ (accessed 2 August 2019).

^{A.2}<https://www.cge.asso.fr/themencode-pdf-viewer/?file=https://www.cge.asso.fr/wp-content/uploads/2018/06/2018-06-19-Rapport-2018.pdf> (accessed 2 August 2019).

Grouping of college majors. The above data sources can be combined to compute the number of female and male master’s students who graduated from university in 2015 or from a *Grande École* in 2016, separately by college major.

The Ministry of Higher Education’s official classification comprises 54 college majors. For the purpose of our analysis, we group these college majors into the following broad categories:

- Non-STEM majors (35 in total): this category includes master’s degree programs in law, economics, management, humanities, psychology, social sciences, medicine, pharmacy, sports studies as well as degrees from non-STEM *Grande Écoles* (e.g. business schools, schools of journalism, schools of architecture).
- STEM majors (19 in total): this category includes master’s degree programs in STEM fields as well as degrees from engineering schools (*Grande Écoles d’ingénieurs*).
- Among STEM majors, we distinguish between engineering schools (all of which are selective and are classified as a single major) and non-selective STEM master’s degrees at university (18 in total).
- Among non-selective STEM majors, we further distinguish between male-dominated majors (16 in total) and female-dominated majors (2 in total: chemistry and earth and life sciences), based on whether the share of female students among master’s graduates in the corresponding field of study is below or above 50%. This distinction does not apply to selective STEM majors, since almost all engineering schools are male-dominated.

Earnings information. The EIPDM and EIDGE surveys provide information on graduates’ average median gross salary (*salaires brut annuel médian*) separately by gender and college major. Starting wages are measured 18 months after graduation for master’s graduates and 24 months after graduation for *Grandes Écoles* graduates. Note that since we do not have access to the individual-level survey data, median earnings by broad categories of college majors can only be approximated as the average of the median earnings in each of the majors that form these broad categories.

A.2 College Majors and the Gender Pay Gap

Combining the above data sources, we provide descriptive evidence on the median starting wages of female and male graduates across the broad categories of college majors. We then analyse the contribution of gender segregation in college majors to the overall entry-level gender pay gap.

Gender composition of STEM and non-STEM majors. The first three columns of Table A1 show the distribution of master’s-level graduates across the broad categories of college majors defined above, along with the share of female graduates in each category. The summary statistics indicate that while female students represent 52% of master’s level graduates, they are strongly under-represented in STEM majors (34%). Female under-representation is more pronounced in selective (male-dominated) STEM majors (female share: 30%) than in non-selective STEM majors (female share: 40%). Among non-selective STEM majors, female students represent only 29% of graduates in male-dominated fields such as mathematics, physics, or computer science, compared to 60% of graduates in female-dominated fields such as chemistry and earth and life sciences.

Starting wages of STEM and non-STEM graduates. The comparison of starting wages by broad college major category confirms that female graduates tend to be over-represented in lower-paying majors (see columns 3–5 of Table A1). Female graduates holding a STEM degree

have a median starting wage of €29,984, which is 7.4% higher than the median starting wage of female graduates holding a non-STEM degree (€27,913). Strikingly, the wage premium for female graduates in STEM appears to be almost entirely driven by selective (male-dominated) STEM degrees (16.4%). By contrast, the wage premium attached to non-selective STEM degrees is close to zero (−0.5%). The low apparent return to non-selective STEM degrees masks substantially different returns between male-dominated and female-dominated majors: while the wage premium attached to male-dominated non-selective STEM majors is of 4.2% for female graduates compared to non-STEM majors, a wage penalty of 4.7% is attached to female-dominated non-selective STEM majors.

Female under-representation in STEM: contribution to the gender pay gap. The last three columns of Table A1 indicate that across all categories of programs, male graduates earn a median annual starting wage of €32,122, compared to €28,411 for female graduates. This amounts to an overall gender pay gap of €3,711 per year, or 11.6% of male pay.

Although the over-representation of female graduates in lower-paying non-STEM and female-dominated STEM majors is a likely contributor to the overall gender pay gap, it is clearly not the sole cause, as gender differences in median earnings are observed within each broad category of college majors. Interestingly, however, the gender wage gap is lower in each category of STEM majors than in non-STEM majors. This finding is consistent with similar evidence for the U.S. (Beede et al., 2011).

To shed light on the contribution of gender segregation in fields of study to the overall entry-level gender pay gap, we adopt a method similar to that used by McDonald and Thornton (2007) in estimating what the overall female-male starting wage gap would be if female graduates had the same distribution of college majors as male graduates.

Since our interest is in measuring the specific contribution of the different dimensions of female under-representation in STEM majors (STEM vs. non-STEM, selective vs. non-selective STEM, male-dominated vs. female-dominated non-selective STEM), we construct counterfactual wage gaps by considering increasingly disaggregated groups of majors.

We start by estimating the counterfactual wage gap if female graduates had the same distribution of STEM vs. non-STEM majors as male graduates, while keeping fixed females' marginal distribution of majors within each of these two broad categories. Put differently, we apply female median earnings in STEM vs. non-STEM degrees to the male distribution of graduates in both categories of majors to recalculate the overall gender pay gap. This counterfactual wage gap, which we denote by $\tilde{\Delta}_w$, is constructed as follows:

$$\tilde{\Delta}_w = 1 - \frac{(\bar{w}_s^f N_s^m + \bar{w}_{ns}^f N_{ns}^m)}{(\bar{w}_s^m N_s^m + \bar{w}_{ns}^m N_{ns}^m)},$$

where \bar{w}_k^g and N_k^g denote the median earnings and the number of graduates of gender g (m : males; f : females) in college major category k (s : STEM; ns : non-STEM), respectively. The contribution of female under-representation in STEM programs to the gender pay gap is then measured as $\Delta_w - \tilde{\Delta}_w$, where Δ_w denotes the observed overall pay gap between male and female graduates.

To measure the contribution of gender segregation between selective and non-selective STEM majors, we construct a second counterfactual wage gap similarly, except that college majors are now grouped into three categories: non-STEM, selective STEM, and non-selective STEM. To measure the contribution of gender segregation between male-dominated and female-dominated STEM majors, we repeat this exercise after grouping college majors into four categories: non-STEM, selective STEM, non-selective male-dominated STEM, and non-selective female-dominated STEM. The contribution of gender segregation between majors within both

male- and female-dominated non-selective STEM is measured by ungrouping all STEM majors. Finally, we ungroup all non-STEM majors to evaluate the contribution of gender segregation between non-STEM majors. The corresponding counterfactual measures what the overall gender gap would be if women had the same distribution as men across all 54 STEM and non-STEM college majors.

Results. The results of this decomposition exercise are shown in Table A2 along with the observed gender pay gap. The contributions of gender segregation between the different categories of college majors to the gender pay gap are reported in column 1 and are expressed as percentages of the total in column 2. We find that the gender imbalances across all college majors “explain” 40% of the gender pay gap among college graduates. Two-thirds of this explained part (27.7% of the total wage gap) can be attributed to the unequal representation of female and male graduates in STEM vs. non-STEM majors, on the one hand, and between the different majors within STEM, on the other hand. The remain third of the explained part of the gap (12.3% of the total) is due to gender segregation between non-STEM majors, the lowest-paying majors (humanities) being typically more female-dominated (77%) than the highest-paying ones (law and economics, where the female share is 59%).

The 27.7% STEM-related gender pay gap can be decomposed as follows. Increasing the share of female graduates holding a STEM degree to that of males without changing females’ marginal distribution of STEM majors is associated with a 14.0% reduction in the gender pay gap. In line with the evidence from Table A1, further reassigning female graduates from non-selective STEM majors to (male-dominated) selective STEM majors in order to match the relative shares of selective and non-selective STEM majors among male graduates would reduce the gender gap by an additional 6.5% from the baseline. Finally, reassigning female graduates from non-selective female-dominated STEM majors to non-selective male-dominated STEM majors would trigger an extra 4.3% reduction in the gender pay gap, while further reassigning female students between majors within male- and female-dominated programs would result in an extra 2.9% reduction from the baseline.

Altogether, these findings suggest that the under-representation of female students in STEM majors accounts for approximately 28% of the entry-level gender pay gap among college graduates in France. Almost half of this STEM-related gender pay gap can be attributed to the fact that within STEM majors, female graduates are relatively less likely than males to be enrolled in those with the largest wage premium, i.e. the selective and male-dominated STEM majors.

Table A1 – Starting Wage Among College Graduates Holding a Master’s Degree or Equivalent, Classes of 2015/16

	Graduates: classes of 2015/16			Wage 18/24 months after graduation (survey)				
	Number of graduates	% of total	Female share (%)	Female graduates		Male graduates		Gender pay gap (%)
				Median wage (euros)	Relative Median wage (non-STEM majors: 100)	Median wage (euros)	Relative Median wage (non-STEM majors: 100)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All majors (54)	166,600	100.0	51.5	28,411	-	32,122	-	11.6
Non-STEM majors (35)	106,997	64.2	61.1	27,913	100.0	31,302	100.0	10.8
STEM majors (19)	59,603	35.8	34.3	29,984	107.4	32,972	105.3	9.1
<i>of which:</i>								
Selective (male-dominated) STEM majors (Engineering schools)	31,463	18.9	29.7	32,500	116.4	34,800	111.2	6.6
Non-Selective STEM majors (18)	28,140	16.9	39.6	27,767	99.5	30,530	97.5	9.1
<i>of which:</i>								
Male-dominated majors (15)	18,874	11.3	29.4	29,077	104.2	31,371	100.2	7.3
Female-dominated majors (3)	9,266	5.6	60.3	26,596	95.3	27,581	88.1	3.6

Notes: This table reports summary statistics on gender segregation and gender pay gaps for the population of college graduates who obtained their master’s degree (or equivalent) in 2015 or 2016. The 54 college majors are grouped into two broad categories: non-STEM majors (master’s degrees in economics, management, humanities, psychology, social sciences, sports studies, medicine, pharmacy, and non-STEM *Grandes Écoles* such as business schools or schools of journalism) and STEM majors (master’s degrees in STEM fields and degrees from engineering schools); STEM majors are further broken down between selective (engineering schools) and non-selective majors (master’s degree at university); among non-selective majors, we distinguish between male-dominated and female-dominated majors, based on whether the share of female graduates in the corresponding field of study is below or above 50%. Column 1 shows the number of graduates per broad category of college majors using the administrative dataset SISE 2015/16 (for university graduates who obtained their master’s degree in 2016) and the EIDGE survey (for students who graduated from *Grandes Écoles* in 2016). Median gross annual wages (columns 4 and 6) are computed from aggregate statistics by gender and college major from the EIPDM and EIDGE surveys. Entry-level wages are measured 18 months after graduation for master’s graduates and 24 months after graduation for *Grandes Écoles* graduates. Median wages by broad categories of college majors are approximated as the average of the median wages in each of the majors that form these broad categories.

Sources: Columns 1–3: SISE 2015/16 and Enquête sur l’Insertion des Diplômés des Grandes Écoles 2018 (EIDGE) (CGE, 2018); columns 4–8: Enquête d’Insertion Professionnelle à 30 Mois des Diplômés de Master 2015 (EIPDM) (MESRI, 2018) and EIDGE.

Table A2 – Contribution of Gender Segregation in College Majors to the Entry-Level Gender Wage Gap Among College Graduates, Classes of 2015/16

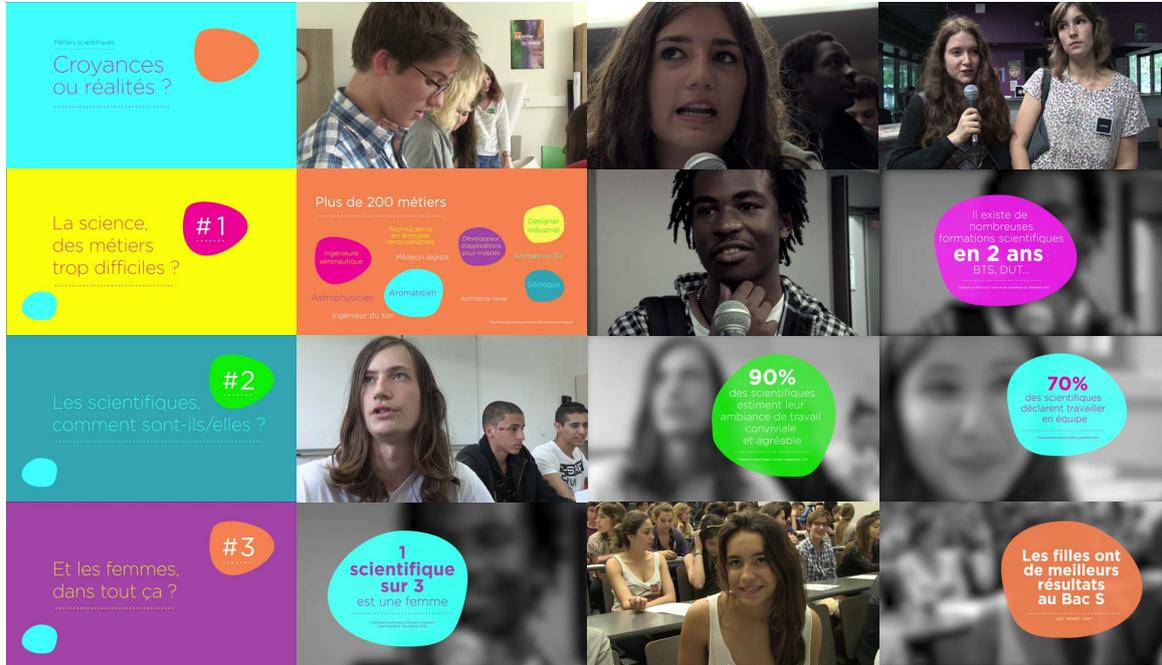
	Gender pay gap (relative to male pay) (1)	Share of the gender wage gap (2)
Total wage gap	0.116	100.0%
<i>Contribution of gender segregation in college majors to the wage gap:</i>		
Explained by unequal gender distribution between majors	0.046	40.0%
<i>of which:</i>		
between STEM/non-STEM majors and between majors within STEM	0.032	27.7%
<i>of which:</i>		
between STEM and non-STEM majors	0.016	14.0%
between selective and non-selective STEM majors	0.007	6.5%
between male- and female-dominated non-selective STEM majors	0.005	4.3%
between majors within male- and female-dominated non-selective STEM	0.003	2.9%
between majors within non-STEM	0.014	12.3%
Unexplained by unequal gender distribution between majors	0.069	60.0%

Notes: This table provides a decomposition of the total entry-level wage gap between male and female college graduates who obtained their master’s degree or equivalent in 2015 (university graduates) or in 2016 (*Grandes Écoles* graduates). Entry-level wages are measured as median annual gross wages by gender and college major, 18 months after graduation for master’s graduates, and 24 months after graduation for *Grandes Écoles* graduates. To measure the contribution of the unequal gender representation across college majors, counterfactual wage gaps are constructed using increasingly disaggregated groups of college majors. The contribution of gender segregation between STEM and non-STEM majors is measured as the observed gender wage gap minus the counterfactual wage gap that would be observed if female graduates had the same distribution of STEM and non-STEM majors as male graduates, while keeping fixed females’ marginal distribution of majors within each of these two broad categories. The contribution of gender segregation between selective and non-selective STEM majors is estimated similarly, except that the counterfactual gender wage gap is estimated by reassigning female graduates from non-selective STEM majors to selective STEM majors to match the relative shares of selective and non-selective STEM majors among male graduates. The other components of the gender wage gap are measured by sequentially ungrouping college majors to compute counterfactual gender wage gaps. The contributions of gender segregation between the different categories of college majors to the gender wage gap are shown in column 1 and are expressed as percentages of the total in column 2.

Sources: See notes of Table A1.

B Program Details

A. First Video: “Jobs in Science: Beliefs or Reality?”



B. Second Video: “Are we All Equal in Science?”

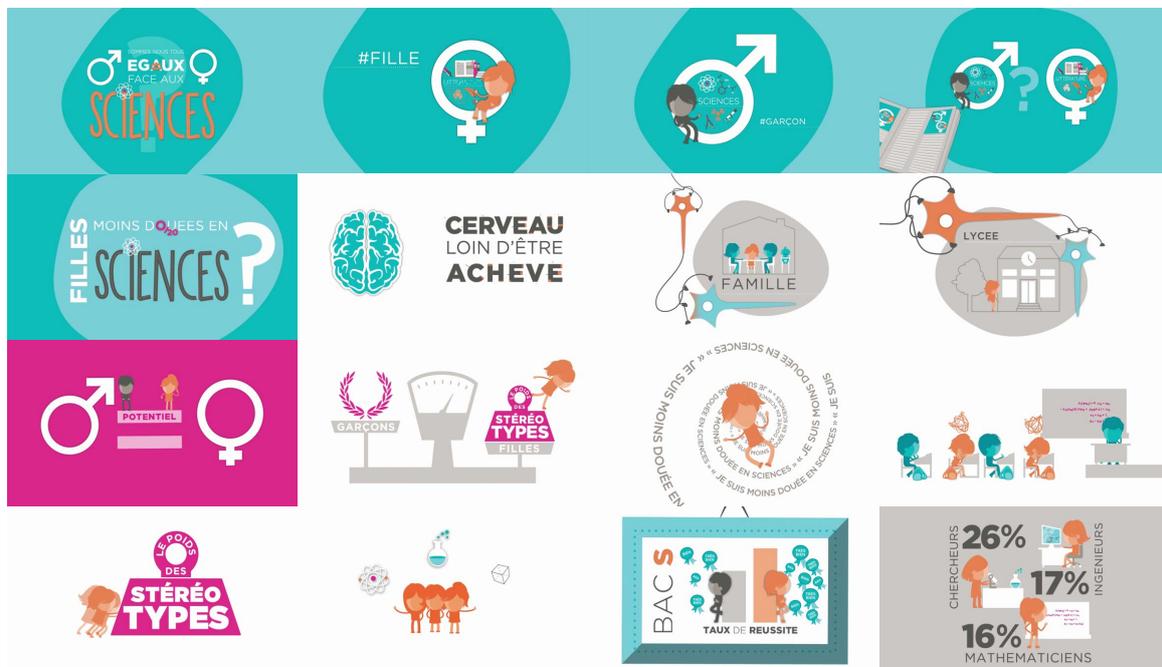


Figure B1 – Screenshots of the Two Videos Shown During the Role Model Interventions

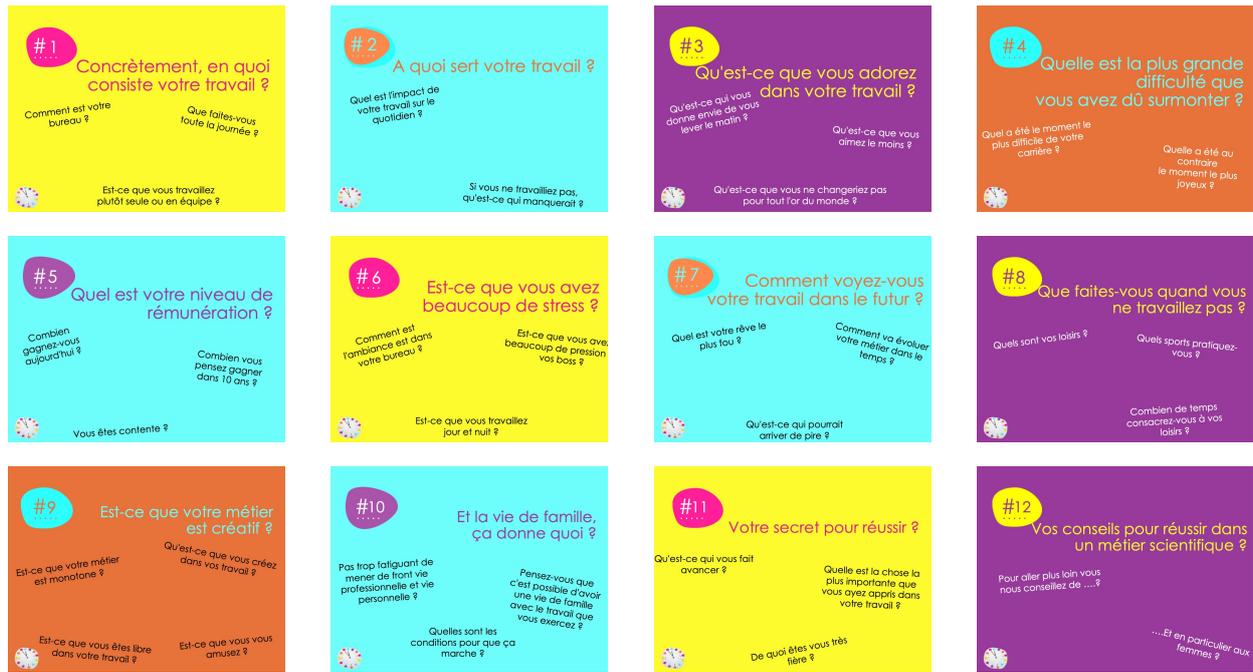


Figure B2 – Screenshots of the Slides Provided to the Role Models to Describe their own Experience

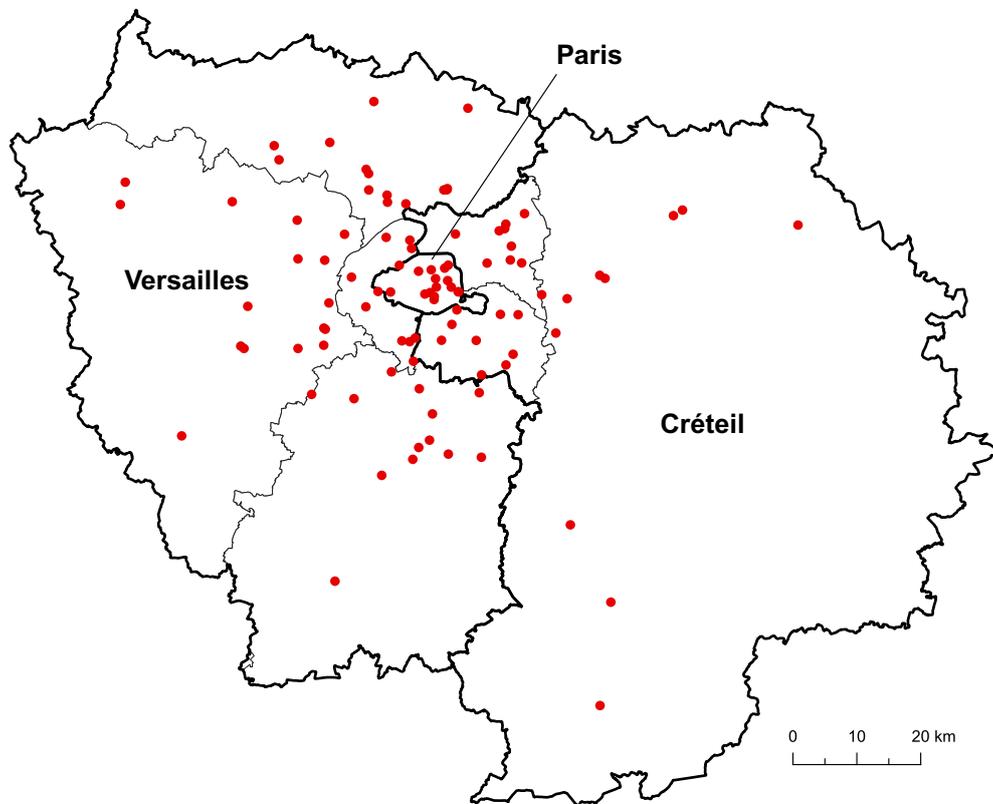


Figure B3 – Participating High Schools

Notes: The thick lines represent the boundaries of the three education districts (*académies*) of the Paris region (Paris, Créteil and Versailles). The solid circles show the location of the 98 high schools that participated in the program evaluation. The shapefile for the administrative divisions of the Paris region (*départements*) were obtained from APUR (2018).

C Student-Level Administrative Data

This appendix describes the administrative data that we use to complement the information from the student survey (Section C.1) and provides details about the classification of STEM undergraduate programs (Section C.2).

C.1 Data Sources

For the purpose of the empirical analysis, we matched the data from our post-intervention student survey with three administrative datasets. These data were linked using an encrypted version of the French national student identifier (*Identifiant National Élève*).

High school enrolment data. Students' socio-demographic characteristics and enrolment status are obtained from the *Bases Élèves Académiques* (BEA) for academic years 2012/13 to 2016/17 (DAPEP, 2017; PAPP, 2017; SSA, 2017). These comprehensive administrative registers, which were provided by the three education districts of the Paris region (Paris, Créteil, and Versailles), cover the universe of students enrolled in the public and private high schools operating in the three districts. They also cover students enrolled in selective undergraduate programs, i.e. *Classes préparatoires aux Grandes Écoles* (CPGE) and *Sections de technicien supérieur* (STS), as these programs are located in high schools. The BEA data provide basic information on students' demographics (gender, date and country of birth, number of siblings), their parents' two-digit occupation, and detailed information on their enrolment status (school and class attended, elective courses taken). Students' socioeconomic status (SES) is measured using the French Ministry of Education's official classification, which uses the occupation of the child's legal guardian to define four groups of SES: high (company managers, executives, liberal professions, engineers, intellectual occupations, arts professions), medium-high (technicians and associate professionals), medium-low (farmers, craft and trades workers, service and sales workers), and low (manual workers and persons without employment).

University enrolment data. To track Grade 12 (science track) students' enrolment outcomes in non-selective undergraduate programs (*Licence*), we use a separate administrative data source, the *Système d'Information sur le Suivi de l'Étudiant* (SISE) (MESRI-DGESIP/DGRI-SIES, 2017), which is managed by the Statistical Office of the French Ministry of Higher Education (Sous-Direction des Systèmes d'Information et des Études Statistiques). This dataset, which covers the academic years 2012/13 to 2016/17, records all students enrolled in the French higher education system outside CPGE and STS, except for the small fraction of students enrolled in undergraduate programs leading to paramedical and social care qualifications.

Data on student performance. The third dataset, the *Organisation des Concours et Examens Académiques et Nationaux* (OCEAN) (MENJ-DEPP, 2017), contains students' individual exam results for the *Diplôme national du brevet* (DNB), which middle school students take at the end of Grade 9, and for the *Baccalauréat*, which high school students take at the end of Grade 12. Access to this dataset, which covers the exams years 2010 to 2016, was provided by the Statistical Office of the French Ministry of Education (Direction de l'Évaluation, de la Prospective et de la Performance).

C.2 Classification of STEM Undergraduate Programs

The enrolment status of Grade 12 (science track) students in the year following the intervention, i.e. 2016/17, is measured by combing the information from the BEA and SISE datasets. For the

purpose of our analysis, we use two alternative classifications of STEM undergraduate programs, based on whether they are (i) selective or non-selective, and (ii) male- or female-dominated.

Selective vs. non-selective STEM programs.

- *Selective STEM*: This category includes all CPGE programs with a specialization in STEM, i.e. mathematics, physics and engineering science (MPSI), physics, chemistry and engineering science (PCSI), biology, chemistry, physics and earth sciences (BCPST), and physics, technology, and engineering science (PTSI). It also includes a small number of selective programs in engineering schools that recruit their students directly after high school graduation, as well as selective technical/vocational undergraduate programs (STS) that specialize in STEM fields.
- *Non-selective STEM*: This category includes non-selective university bachelor's degree programs (*Licence*) that specialize in STEM fields: maths, physics, chemistry, earth and life sciences, and computer science. Undergraduate programs in medicine and pharmacy are not included in this category.

Male- vs. female-dominated STEM programs.

- *Male-dominated STEM*: STEM programs are classified as being male-dominated if the share of female students in the corresponding field is below 50%. This category includes the selective programs (CPGE and STS) and non-selective programs (*Licence*) that specialize in mathematics, physics, chemistry, computer science, and engineering.
- *Female-dominated STEM*: STEM programs are classified as being female-dominated if the share of female students in the corresponding field is above 50%. This category includes both selective (CPGE and STS) and non-selective programs (*Licence*) that specialize in earth and life sciences.

If a student is enrolled in multiple higher education programs, we only consider the most selective among these programs, with CPGE taking precedence over STS, and STS taking precedence over university undergraduate degree programs.

Note that selective STEM programs and male-dominated STEM programs are partly overlapping: in 2016/17, 49% of undergraduate students in male-dominated STEM fields were enrolled in selective programs, while 95% of students in selective programs were in male-dominated STEM fields.

D Construction of Synthetic Indices and Multiple Hypotheses Testing

This appendix discusses the construction of the synthetic indices that we use to measure the effects of role model interventions on students’ perceptions (Section D.1) and provides further details on the adjustment of p -values to correct for multiple hypotheses testing (Section D.2).

D.1 Construction of Synthetic Indices

The student survey questionnaire aimed at measuring the effects of role model interventions on students’ perceptions and self-concept along five dimensions: (i) general perceptions of science-related careers, (ii) perceptions of gender roles in science, (iii) taste for science subjects, (iv) self-concept in maths, and (v) science-related career aspirations.

We use the survey items listed below to construct synthetic indices for each of these five dimensions. When responses are measured on a Likert scale, i.e. when respondents specify their level of agreement or disagreement with a statement on a symmetric agree-disagree scale, the item responses are recoded so that higher values correspond to less stereotypical or negative perceptions (see details below). We then take the average of each student’s responses to the different questions.^{A.3} We checked that the indices yield similar results if item responses are converted to binary variables before taking the average across items. Finally, to facilitate interpretation, we normalize each index to have a mean of zero and a standard deviation of one in the control group.

Below is the list of the individual items that are included in each of the five synthetic indices. Unless otherwise specified, these items use a four-point Likert response scale such that 1=Strongly agree, 2=Agree, 3=Disagree, and 4=Strongly disagree. Items marked with a * have been recoded such that a value of 1 means “Strongly disagree” and 4 means “Strongly agree”.

1. *Positive perceptions of science-related careers* (5 items): “Science-related jobs require more years of schooling”; “Science-related jobs are monotonous”; “Science-related jobs are rather solitary”; “Science-related jobs pay higher wages*”; “It is difficult to have a fulfilling family life when working as a scientist”.
2. *Equal gender aptitude for maths* (2 items): “Women and men are born with different brains”; “Men are more gifted than women in mathematics”.
3. *Taste for science subject* (4 items): Enjoys maths (on a scale from 0 “not at all” to 10 “very much”); Enjoys physics and chemistry (on a scale from 0 to 10); Enjoys earth and life sciences (on a scale from 0 to 10); “I like science in general*”.
4. *Self-concept in maths* (4 items): Self-assessed performance in match (very weak/weak/average/good/very good); “I feel lost when I try to solve a maths problem”; “I often worry that I will struggle in maths class”; “If I make enough effort, I can do well in science subjects”.
5. *Science-related career aspirations* (4 items): “Some jobs in science are interesting*”; “ I could see myself working in a science-related job later in life*”; Interested in at least one of six STEM job out of a list of ten STEM and non-STEM occupations^{A.4} (0/1 variable); “Career and earnings prospects play an important role in my choice of study” (on a scale from 0 “not at all” to 10 “very much”).

^{A.3}This procedure is inspired from the KidiQol test used in the psychological literature to measure children’s life satisfaction (Gayral-Taminh et al., 2005).

^{A.4}The STEM occupations in the list were: chemist, computer scientist, engineer, industrial designer, renewable energy technician, and researcher in biology. The non-STEM occupations were lawyer, pharmacist, physician, and psychologist.

D.2 Multiple Hypotheses Testing

Consistent with the recent applied literature, we systematically use the False Discovery Rate (FDR) control, which designates the expected proportion of all rejections that are type-I errors. Specifically, we use the sharpened two-stage q -values introduced in Benjamini et al. (2006) and described in Anderson (2008).

We study nine main outcomes throughout the paper: (i) enrolment in a STEM track (for Grade 10 students) or STEM major (for Grade 12 students); (ii) five synthetic indices capturing positive perceptions of science-related careers, equal gender aptitude for maths, taste for science subjects, self-concept in maths, and science-related career aspirations (see Section D.1); and (iii) three variables capturing different facets of gender role in science that cannot be combined into a single index, which are based on the survey items asking students whether they agree or disagree with the statements “There are more men than women in science-related jobs”, “Women don’t really like science”, and “Women face discrimination in science-related jobs”. These nine outcomes are our primary outcomes of interest and we therefore systematically provide (along with standard p -values) p -values that are adjusted for multiple testing across them (q -values), separately by grade level and gender.

For each of the five synthetic indices described in the previous section, we report separate treatment effect estimates for the individual components of the index and provide standard p -values for the corresponding estimates along with p -values adjusted for multiple testing across the index components, separately by grade level and gender.

As we further split enrolment in STEM into different types of STEM tracks or majors (e.g. selective STEM, non-selective STEM, male-dominated STEM, and female-dominated STEM in Grade 12), we provide adjusted p -values for multiple testing across these different STEM tracks or majors, separately by grade level and gender. Given the importance of some of these specific STEM majors in our analyses, it could also be justified to consider them jointly with the primary outcomes described above. We have checked that, in practice, this alternative choice has little effect on the reported q -values.

Finally, treatment effects on other outcomes, such as the probabilities of being enrolled in a non-STEM major or of not being enrolled in an education program in the year following the classroom interventions, are also reported in the paper for the sake of completeness and clarity. Since these are not outcomes of direct interest in our study or are complements of other outcomes of interest, we do not consider them in the multiple testing corrections.

E Summary Statistics and Balancing Tests

Table E1 – Experimental Sample: Summary Statistics (School-Level)

	High schools operating in the Paris region (1)	Participating high schools (2)
Number of high schools	489	98
Share private	0.339	0.173
Education district: Paris	0.243	0.153
Education district: Créteil	0.348	0.296
Education district: Versailles	0.409	0.551
Number of students	644	924
Share of female students	0.524	0.526
Share of high SES students	0.423	0.391
Share of medium-high SES students	0.116	0.128
Share of medium-low SES students	0.243	0.239
Share of low SES students	0.218	0.241
Pass rate on Baccalauréat exam in 2015	0.913	0.910

Notes: This table compares the characteristics of high schools that participated in the program evaluation in 2015/16 to the characteristics of all general-track high schools operating in the Paris region. The summary statistics are computed from the *Bases Élèves académiques* of the three education districts of Paris, Créteil, and Versailles for the academic year 2015/16. The *Baccalauréat* pass rate is computed for students who were enrolled in Grade 12 in 2014/15, i.e. in the year before the intervention, and who took the exams in the general or technical tracks.

Table E2 – Experimental Sample: Summary Statistics (Student-Level)

	High schools operating in the Paris region (1)	Participating high schools			
		Classes selected for random assignment (2)	Classes not selected for random assignment (3)	Diff. (2)–(3) (4)	<i>p</i> -value of diff. (2)–(3) (5)
Panel A. Grade 10					
Number of students	115,720	13,700	19,147		
Number of classes	3,627	416	592		
Female	0.525	0.529	0.525	0.004	0.503
Age (years)	15.14	15.13	15.14	–0.016	0.004
Non-French	0.063	0.060	0.068	–0.008	0.005
High SES	0.403	0.381	0.361	0.020	0.000
Medium-high SES	0.118	0.128	0.127	0.001	0.713
Medium-low SES	0.239	0.241	0.248	–0.006	0.203
Low SES	0.240	0.249	0.265	–0.015	0.002
Number of siblings	1.44	1.49	1.50	–0.016	0.255
Class size	32.22	33.25	32.48	0.753	0.000
DNB percentile rank in maths	57.69	58.48	55.10	3.382	0.000
DNB percentile rank in French	57.23	57.85	55.75	2.096	0.000
Panel B. Grade 12 (science track)					
Number of students	38,582	5,751	5,623		
Number of classes	1,267	185	179		
Female	0.459	0.492	0.417	0.075	0.000
Age (years)	17.11	17.12	17.10	0.023	0.043
Non-French	0.045	0.051	0.037	0.014	0.000
High SES	0.527	0.464	0.535	–0.071	0.000
Medium-high SES	0.115	0.136	0.126	0.010	0.113
Medium-low SES	0.198	0.209	0.180	0.029	0.000
Low SES	0.160	0.192	0.160	0.032	0.000
Number of siblings	1.43	1.50	1.44	0.054	0.007
Class size	31.43	31.97	32.08	–0.153	0.069
DNB percentile rank in maths	76.25	74.06	76.20	–2.127	0.000
DNB percentile rank in French	70.78	69.61	69.78	–0.169	0.704

Notes: This table compares the characteristics of Grade 10 and Grade 12 (science track) students enrolled in the high schools that participated in the program evaluation to the characteristics of all Grade 10 and Grade 12 (science track) students enrolled in general-track high schools in the Paris region. In participating schools, the classes that were selected by principals for random assignment to treatment are compared to classes that were not selected. The summary statistics are computed from the *Bases Élèves académiques* of the three education districts of Paris, Créteil, and Versailles for the academic year 2015/16. French and maths scores are from the exams of the *Diplôme national du brevet* (DNB) that middle school students take at the end of Grade 9.

Table E3 – Post-Intervention Role Model Survey: Summary Statistics

	Role model background			Difference (3)–(2) (4)	<i>p</i> -value of diff. (5)
	All (1)	Profes- sionals (2)	Resear- chers (3)		
<i>A. Adults present during the intervention</i>					
Teacher was present	0.890	0.883	0.896	0.014	0.773
Teacher’s subject: science ^a	0.600	0.596	0.603	0.007	0.922
Teacher’s gender: female	0.551	0.533	0.565	0.032	0.653
Teacher showed interest	0.696	0.634	0.745	0.111	0.098
Other adult present beside teacher	0.348	0.392	0.315	–0.077	0.236
<i>B. General atmosphere during the intervention</i>					
Students were very interested	0.423	0.425	0.422	–0.004	0.963
Students were very engaged in the discussion	0.386	0.378	0.392	0.014	0.838
Students were inattentive	0.134	0.165	0.110	–0.055	0.259
Powerpoint worked well	0.963	0.938	0.982	0.045	0.172
Videos worked well	0.888	0.891	0.886	–0.004	0.940
Logistical problems	0.160	0.185	0.140	–0.044	0.487
Talk interrupted due to discipline problems	0.068	0.079	0.060	–0.018	0.652
<i>C. Topics addressed during the intervention</i>					
“Science is everywhere”	1.000	1.000	1.000	0.000	–
“Jobs in science are fulfilling”	0.990	1.000	0.982	–0.018	0.080
“Jobs in science are for girls too”	1.000	1.000	1.000	0.000	–
“Jobs in science pay well”	0.866	0.890	0.849	–0.040	0.516
Short videos	0.980	0.969	0.988	0.019	0.436
<i>D. Students’ responsiveness to topics addressed during the intervention</i>					
Very responsive to “science is everywhere”	0.430	0.378	0.470	0.092	0.360
Very responsive to “jobs in science are fulfilling”	0.352	0.402	0.313	–0.088	0.333
Very responsive to “jobs in science are for girls too”	0.375	0.354	0.392	0.037	0.674
Very responsive to “jobs in science pay well”	0.387	0.263	0.476	0.213	0.042
Very responsive to the short videos	0.546	0.488	0.590	0.102	0.339
<i>E. Overall impression of the role model</i>					
Were gender stereotypes strong among students?					
Yes, very much	0.089	0.039	0.128	0.089	0.057
Rather yes	0.313	0.276	0.341	0.066	0.337
Rather no/not at all	0.598	0.685	0.530	–0.155	0.074
How did the classroom intervention go?					
Very well	0.556	0.535	0.572	0.037	0.670
Well	0.369	0.386	0.355	–0.030	0.716
Average/not so well/not well at all	0.075	0.079	0.072	–0.006	0.821
Was the intervention well suited to the students?					
Yes, very much	0.474	0.449	0.494	0.045	0.661
Rather yes	0.471	0.504	0.446	–0.058	0.574
Rather no/not at all	0.055	0.047	0.060	0.013	0.592
Number of role models	56	21	35		
Number of classroom interventions	290	124	166		

Notes: The summary statistics are computed from the post-intervention role model survey that was administered online to collect feedback about the classroom visits. The unit of observation is a classroom intervention. ^a The science subjects taught in high school are mathematics, physics and chemistry, and earth and life sciences.

Table E4 – Compliance with Random Assignment

	All classes (1)	Classes assigned to	
		Control group (2)	Treatment group (3)
Panel A. Grade 10			
Number of classes visited by a role model	199	2	197
Number of classes not visited by a role model	217	205	12
Number of students	13,700	6,801	6,899
Student-level compliance with random assignment	0.97	0.99	0.94
Panel B. Grade 12 (science track)			
Number of classes visited by a role model	91	2	89
Number of classes not visited by a role model	94	90	4
Number of students	5,751	2,853	2,898
Student-level compliance with random assignment	0.97	0.98	0.95

Notes: This table reports compliance with the random assignment of Grade 10 and Grade 12 (science track) classes to the treatment and control groups. Two-way non-compliance was due to either classes in the treatment not being visited by a role model or to classes in the control group being visited by a role model.

Table E5 – Student Post-Treatment Survey: Response Rates

	Control group (1)	Treatment group (2)	Within school	
			Difference T–C (3)	<i>p</i> -value of diff. (4)
Panel A. Grade 10				
Survey response rate	0.879	0.905	0.026 (0.012)	0.026
Number of students	6,801	6,899	13,700	
Panel B. Grade 12 (science track)				
Survey response rate	0.909	0.912	0.005 (0.012)	0.693
Number of students	2,853	2,898	5,751	

Notes: This table reports the student survey response rate for students in the Grade 10 and Grade 12 (science track) classes that participated in the program. The response rates are computed based on the list of all students who were recorded in the *Bases Élèves académiques* as being enrolled in the participating classes during the academic year 2015/16. Columns 1 and 2 show the response rate of students in the control and treatment groups, respectively. Column 3 reports the coefficient from the regression of survey participation on the treatment group indicator, with *p*-values reported in column 4. The regression controls for school fixed effects to account for the fact that randomization was stratified by school. Standard errors (in parentheses) are adjusted for clustering at the unit of randomization (class).

Table E6 – Treatment-Control Balance: Survey Respondents

	Control group (1)	Treatment group (2)	Within school	
			Difference T–C (3)	<i>p</i> -value of diff. (4)
Panel A. Grade 10				
<i>Student characteristics</i>				
Female	0.538	0.521	–0.014	0.160
Age (years)	15.12	15.11	–0.01	0.248
Non-French	0.057	0.060	0.003	0.528
High SES	0.382	0.389	0.005	0.496
Medium- high SES	0.133	0.127	–0.006	0.248
Medium-low SES	0.245	0.235	–0.009	0.200
Low SES	0.240	0.248	0.010	0.158
Number of siblings	1.483	1.482	–0.001	0.954
Class size	33.23	33.25	0.02	0.837
At least one science elective course	0.394	0.402	0.009	0.693
At least one standard elective course	0.773	0.738	–0.032	0.132
DNB percentile rank in maths	59.09	59.04	–0.18	0.760
DNB percentile rank in French	58.14	58.41	0.08	0.893
<i>Test of joint significance</i>	<i>F</i> -stat: 0.634 (<i>p</i> -value: 0.813)			
<i>Predicted track in Grade 11</i>				
Grade 11: Science track	0.454	0.459	0.004	0.577
Grade 11: Science - general track	0.381	0.385	0.003	0.666
Grade 11: Science - technical track	0.073	0.074	0.001	0.670
N	5,981	6,245	12,226	
Panel B. Grade 12 (science track)				
<i>Student characteristics</i>				
Female	0.504	0.489	–0.014	0.319
Age (years)	17.13	17.09	–0.05	0.001
Non-French	0.053	0.046	–0.008	0.129
High SES	0.446	0.481	0.038	0.001
Medium-high SES	0.138	0.138	–0.000	0.979
Medium-low SES	0.219	0.196	–0.022	0.001
Low SES	0.197	0.184	–0.016	0.086
Number of siblings	1.502	1.487	–0.021	0.355
Class size	31.69	32.12	0.30	0.314
DNB percentile rank in maths	74.52	74.00	–0.09	0.874
DNB percentile rank in French	69.59	70.00	0.68	0.248
<i>Test of joint significance</i>	<i>F</i> -stat: 1.218 (<i>p</i> -value: 0.282)			
<i>Predicted undergraduate major</i>				
Major: STEM	0.395	0.395	0.001	0.807
Major: selective STEM	0.181	0.184	0.005	0.189
Major: male-dominated STEM	0.283	0.284	0.002	0.561
N	2,594	2,642	5,236	

Notes: Each row corresponds to a different linear regression with the dependent variable listed on the left, separately for students in Grade 10 (Panel A) and in Grade 12 (Panel B). The sample is restricted to students who answered the post-intervention survey. Columns 1 and 2 show the average value for students in the control and treatment groups, respectively. Column 3 reports the coefficient from the regression of each variable on the treatment group indicator, with the *p*-value reported in column 4. The regression controls for school fixed effects to account for the fact that randomization was stratified by school, and standard errors are adjusted for clustering at the unit of randomization (class). The *F*-statistic is from a test of the joint significance of the coefficients in a regression of the treatment group indicator on all student characteristics. High school tracks (Panel A) and undergraduate majors (Panel B) are predicted for each student using the coefficients from a linear regression of the corresponding binary variable (e.g. enrolment in a STEM major) on all student characteristics listed in the table. This model is fitted separately by grade level on the sample of students in the control group.

Table E7 – Balancing Test: High Schools Visited by Professionals and Researchers, Grade 10 Students

	High school visited by		Difference (2)–(1)	<i>p</i> -value of diff.
	Researcher (1)	Professional (2)		
<i>School characteristics</i>				
Education district: Paris	0.165	0.167	0.002	0.958
Education district: Créteil	0.273	0.317	0.044	0.321
Education district: Versailles	0.562	0.516	–0.046	0.348
Private school	0.092	0.224	0.132	0.000
Share of female students in 2015/16	0.523	0.527	0.005	0.627
Pass rate on Baccalauréat exam in 2015 ^a	0.904	0.916	0.012	0.041
Grade 10 students: science track in Grade 11 ^b	0.405	0.412	0.006	0.597
Grade 10 students: general science track in Grade 11 ^b	0.341	0.337	–0.005	0.672
Grade 10 students: technical science track in Grade 11 ^b	0.064	0.075	0.011	0.135
<i>Student characteristics</i>				
Female	0.525	0.531	0.007	0.623
Age (years)	15.12	15.13	0.01	0.598
Non-French	0.065	0.057	–0.008	0.185
High SES	0.345	0.410	0.064	0.002
Medium-high SES	0.132	0.125	–0.007	0.322
Medium-low SES	0.250	0.235	–0.015	0.124
Low SES	0.272	0.231	–0.042	0.013
Number of siblings	1.482	1.488	0.007	0.862
Class size	33.38	33.14	–0.25	0.343
At least one science elective course	0.416	0.376	–0.040	0.250
At least one standard elective course	0.772	0.738	–0.034	0.197
DNB percentile rank in maths	57.80	59.02	1.22	0.380
DNB percentile rank in French	56.77	58.71	1.93	0.120
<i>Predicted track in Grade 11</i>				
Grade 11: Science track	0.448	0.454	0.006	0.668
Grade 11: Science - general track	0.374	0.375	0.002	0.915
Grade 11: Science - technical track	0.074	0.079	0.005	0.517
N	6,059	7,641	13,700	

Notes: Each row corresponds to a different linear regression with the dependent variable listed on the left for students enrolled in Grade 10 in 2015/16. Columns 1 and 2 show the average value for students whose high school was visited by a role model with a professional or a research background, respectively. Column 3 reports the coefficient from the regression of each variable on an indicator that takes the value one if the school was visited by a professional and zero if the school was visited by a researcher, with the *p*-value reported in column 4. Standard errors are adjusted for clustering at the class level. High school tracks in Grade 11 are predicted for each student using the coefficients from a linear regression of the corresponding binary variable (e.g. enrolment in the general science track) on all the school and student characteristics listed in the table. This model is fitted on the sample of students in the control group. ^a The *Baccalauréat* pass rate is computed for students who were enrolled in Grade 12 in 2014/15, i.e. in the year before the intervention, and who took the exams in the general or technical tracks. ^b The share of students enrolled in the science track in Grade 11 is computed for students who were enrolled in Grade 10 in 2014/15.

Table E8 – Balancing Test: High Schools Visited by Professionals and Researchers, Grade 12 Students

	High school visited by		Difference (2)–(1) (3)	<i>p</i> -value of diff. (4)
	Researcher (1)	Professional (2)		
<i>School characteristics</i>				
Education district: Paris	0.164	0.163	−0.001	0.985
Education district: Créteil	0.223	0.321	0.098	0.138
Education district: Versailles	0.614	0.517	−0.097	0.195
Private school	0.096	0.244	0.148	0.007
Share of female students in 2015/16	0.533	0.543	0.010	0.379
Pass rate on Baccalauréat exam in 2015 ^a	0.911	0.912	0.002	0.849
Grade 12 (science track) students: STEM major in higher ed. ^b	0.409	0.384	−0.025	0.050
Grade 12 (science track) students: selective STEM in higher ed. ^b	0.191	0.202	0.010	0.484
Grade 12 (science track) students: male-dom. STEM in higher ed. ^b	0.309	0.299	−0.010	0.431
<i>Student characteristics</i>				
Female	0.474	0.505	0.032	0.114
Age (years)	17.14	17.11	−0.03	0.323
Non-French	0.057	0.046	−0.010	0.272
High SES	0.437	0.484	0.046	0.169
Medium-high SES	0.146	0.128	−0.018	0.138
Medium-low SES	0.213	0.205	−0.009	0.544
Low SES	0.203	0.184	−0.019	0.428
Number of siblings	1.454	1.532	0.079	0.100
Class size	32.67	31.44	−1.22	0.026
DNB percentile rank in maths	72.96	74.90	1.94	0.213
DNB percentile rank in French	68.00	70.83	2.83	0.057
<i>Predicted undergraduate major</i>				
Major: STEM	0.392	0.378	−0.013	0.062
Major: selective STEM	0.170	0.181	0.011	0.347
Major: male-dominated STEM	0.277	0.274	−0.003	0.731
N	2,492	3,259	5,751	

Notes: Each row corresponds to a different linear regression with the dependent variable listed on the left for students enrolled in Grade 12 (science track) in 2015/16. Columns 1 and 2 show the average value for students whose high school was visited by a role model with a professional or a research background, respectively. Column 3 reports the coefficient from the regression of each variable on an indicator that takes the value one if the school was visited by a professional and zero if the school was visited by a researcher, with the *p*-value reported in column 4. Standard errors are adjusted for clustering at the class level. Undergraduate majors are predicted for each student using the coefficients from a linear regression of the corresponding binary variable (e.g. enrolment in a STEM major) on all the school and student characteristics listed in the table. This model is fitted on the sample of students in the control group. ^a The *Baccalauréat* pass rate is computed for students who were enrolled in Grade 12 in 2014/15, i.e. in the year before the intervention, and who took the exams in the general or technical tracks. ^b The share of students enrolled in a STEM undergraduate major in higher education is computed for students who were enrolled in Grade 12 (science track) in 2014/15.

Table E9 – Timing of Visits: Summary Statistics by Role Model Background

	All role models	Researchers (Ph.D./ Postdoc)	Professionals (employed by sponsoring firm)	Difference (3)–(2)	<i>p</i> -value of diff. (3)–(2)
	(1)	(2)	(3)	(4)	(5)
Panel A. Timing of classroom interventions					
November 2015	0.17	0.20	0.15	–0.05 (0.08)	0.51
December 2015	0.26	0.28	0.24	–0.05 (0.09)	0.60
January 2016	0.40	0.35	0.43	0.08 (0.10)	0.42
February 2016	0.17	0.15	0.19	0.04 (0.08)	0.62
March 2016	0.01	0.02	0.00	–0.02 (0.02)	0.32
Average nb of days since first visit (17 Nov 2015)	46.1	44.1	47.6	3.49 (6.04)	0.56
N	573	243	330		
Panel B. Time lag between intervention and student survey					
Average nb of days between visit and survey	67.6	71.8	64.5	–7.35 (6.31)	0.25
N	557	239	318		

Notes: Panel A reports the distribution of classroom visits by month of intervention and the average number of days since the first visit (17 November 2015). Panel B reports the average number of days between the classroom visit and the date of the student survey. The statistics are computed for all role models (column 1) and separately for researchers (column 2) and professionals (column 3). Column 4 reports the coefficient from the regression of each variable on an indicator that takes the value one if the classroom was visited by a professional and zero if the school was visited by a researcher, with the *p*-value reported in column 5. Standard errors (shown in parentheses) are adjusted for clustering at the role model \times high school visit level. The date of the visit is missing for 7 out of the 98 participating schools, while the date of the survey is missing for 6 schools.

F Effects of Role Model Interventions: Additional Results

Table F1 – Perceptions of Science-Related Careers

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Positive perceptions of science-related careers (index)	–0.020	0.245*** (0.027)	0.000 [0.001]	0.023	0.162*** (0.027)	0.000 [0.001]	0.013
Science-related jobs require more years of schooling	0.839	–0.087*** (0.010)	0.000 [0.001]	0.849	–0.075*** (0.010)	0.000 [0.001]	0.404
Science-related jobs are monotonous	0.290	–0.034*** (0.011)	0.003 [0.005]	0.318	–0.003 (0.013)	0.788 [0.788]	0.065
Science-related jobs are solitary	0.325	–0.057*** (0.012)	0.000 [0.001]	0.303	–0.059*** (0.011)	0.000 [0.001]	0.870
Science-related jobs pay higher wages	0.637	0.009 (0.014)	0.496 [0.496]	0.668	0.015 (0.013)	0.222 [0.279]	0.718
Hard to maintain work-life balance	0.297	–0.027** (0.011)	0.014 [0.018]	0.283	–0.029*** (0.011)	0.009 [0.016]	0.916
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Positive perceptions of science-related careers (index)	–0.003	0.296*** (0.032)	0.000 [0.001]	0.003	0.171*** (0.033)	0.000 [0.001]	0.002
Science-related jobs require more years of schooling	0.666	–0.113*** (0.016)	0.000 [0.001]	0.719	–0.096*** (0.014)	0.000 [0.001]	0.401
Science-related jobs are monotonous	0.169	–0.013 (0.012)	0.290 [0.291]	0.233	–0.022 (0.017)	0.185 [0.185]	0.615
Science-related jobs are solitary	0.228	–0.083*** (0.012)	0.000 [0.001]	0.206	–0.053*** (0.013)	0.000 [0.001]	0.080
Science-related jobs pay higher wages	0.531	0.063*** (0.018)	0.001 [0.002]	0.576	0.038** (0.016)	0.018 [0.030]	0.327
Hard to maintain work-life balance	0.225	–0.046*** (0.015)	0.002 [0.003]	0.167	–0.015 (0.011)	0.174 [0.185]	0.092
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of classroom interventions on students’ perceptions of science-related careers, separately by grade level and gender. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the synthetic index (highlighted in bold) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values for the individual components of the index are adjusted for multiple testing across the index components, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1.

Table F2 – Gender Differences in Aptitude for Mathematics

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Equal gender aptitude for maths (index)	0.115	0.111*** (0.024)	0.000 [0.001]	−0.134	0.142*** (0.030)	0.000 [0.001]	0.383
M and W are born with different brains	0.211	−0.048*** (0.010)	0.000 [0.001]	0.209	−0.044*** (0.011)	0.000 [0.001]	0.742
Men are more gifted in maths than women	0.186	−0.028*** (0.010)	0.007 [0.007]	0.299	−0.048*** (0.014)	0.000 [0.001]	0.196
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Equal gender aptitude for maths (index)	0.158	0.078*** (0.028)	0.004 [0.007]	−0.161	0.124*** (0.042)	0.003 [0.006]	0.348
M and W are born with different brains	0.143	−0.024** (0.011)	0.026 [0.026]	0.180	−0.032** (0.014)	0.027 [0.055]	0.618
Men are more gifted in maths than women	0.163	−0.028** (0.012)	0.021 [0.026]	0.266	−0.029* (0.016)	0.064 [0.064]	0.947
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on students’ perceptions regarding the aptitude of men and women for mathematics, separately by grade level and gender. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the synthetic index (highlighted in bold) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values for the individual components of the index are adjusted for multiple testing across the index components, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1.

Table F3 – Taste for Science Subjects

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Taste for science subjects (index)	–0.169	–0.033 (0.031)	0.275 [0.414]	0.197	–0.021 (0.026)	0.431 [0.555]	0.704
Enjoys maths (<i>z</i> -score)	–0.147	0.003 (0.030)	0.924 [0.924]	0.186	–0.005 (0.027)	0.844 [0.973]	0.818
Enjoys physics-chemistry (<i>z</i> -score)	–0.170	–0.042 (0.034)	0.222 [0.445]	0.223	–0.022 (0.029)	0.448 [0.896]	0.566
Enjoys earth and life sciences (<i>z</i> -score)	–0.042	–0.052 (0.037)	0.162 [0.445]	0.086	–0.027 (0.034)	0.438 [0.896]	0.492
Enjoys science in general	0.661	–0.011 (0.013)	0.384 [0.512]	0.790	–0.000 (0.011)	0.972 [0.973]	0.453
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Taste for science subjects (index)	–0.002	0.018 (0.033)	0.583 [0.583]	0.002	0.014 (0.040)	0.733 [0.825]	0.924
Enjoys maths (<i>z</i> -score)	–0.097	0.086** (0.036)	0.019 [0.076]	0.100	0.087** (0.039)	0.027 [0.055]	0.976
Enjoys physics-chemistry (<i>z</i> -score)	–0.089	–0.005 (0.043)	0.911 [0.911]	0.102	–0.003 (0.040)	0.944 [0.945]	0.966
Enjoys earth and life sciences (<i>z</i> -score)	0.203	–0.040 (0.038)	0.288 [0.576]	–0.215	–0.070 (0.061)	0.246 [0.328]	0.603
Enjoys science in general	0.918	–0.002 (0.009)	0.770 [0.911]	0.930	0.022*** (0.008)	0.008 [0.034]	0.036
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on students’ taste for science subjects taught at school, separately by grade level and gender. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the synthetic index (highlighted in bold) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values for the individual components of the index are adjusted for multiple testing across the index components, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1.

Table F4 – Self-Concept in Maths

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Self-concept in maths (index)	–0.198	–0.001 (0.028)	0.981 [0.982]	0.231	0.033 (0.029)	0.250 [0.375]	0.324
Self-assessed performance in maths (<i>z</i> -score)	–0.127	–0.013 (0.029)	0.663 [0.663]	0.168	0.016 (0.027)	0.555 [0.700]	0.375
Lost in front of a maths problem	0.553	0.008 (0.013)	0.531 [0.663]	0.344	–0.005 (0.012)	0.700 [0.700]	0.437
Worried when thinking about maths	0.617	–0.029** (0.013)	0.025 [0.093]	0.420	–0.030** (0.014)	0.027 [0.109]	0.919
Can succeed in science subjects if puts in effort	0.843	0.018** (0.009)	0.046 [0.093]	0.883	–0.005 (0.008)	0.511 [0.700]	0.061
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Self-concept in maths (index)	–0.184	0.051 (0.035)	0.139 [0.157]	0.187	0.068** (0.033)	0.038 [0.057]	0.695
Self-assessed performance in maths (<i>z</i> -score)	–0.126	0.044 (0.034)	0.202 [0.270]	0.123	0.080** (0.034)	0.017 [0.035]	0.387
Lost in front of a maths problem	0.486	–0.032* (0.019)	0.091 [0.183]	0.325	–0.032** (0.016)	0.050 [0.067]	0.980
Worried when thinking about maths	0.560	–0.037** (0.018)	0.044 [0.175]	0.384	–0.050*** (0.016)	0.001 [0.006]	0.575
Can succeed in science subjects if puts in effort	0.942	–0.002 (0.008)	0.751 [0.752]	0.949	0.007 (0.007)	0.341 [0.341]	0.396
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on students’ self-concept in maths, separately by grade level and gender. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the synthetic index (highlighted in bold) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values for the individual components of the index are adjusted for multiple testing across the index components, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1.

Table F5 – Science-Related Career Aspirations

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Science-related career aspirations (index)	–0.103	0.005 (0.029)	0.851 [0.970]	0.120	0.004 (0.027)	0.871 [0.872]	0.977
Some jobs in science are interesting	0.845	0.018** (0.009)	0.042 [0.167]	0.854	–0.005 (0.009)	0.586 [0.636]	0.059
Would consider a job in science	0.466	–0.003 (0.013)	0.823 [0.825]	0.587	0.023* (0.012)	0.056 [0.224]	0.107
Interested in at least one STEM job ^a	0.642	0.003 (0.012)	0.825 [0.825]	0.849	0.009 (0.009)	0.332 [0.636]	0.671
Wage prospects important in career choice (<i>z</i> -score)	–0.045	–0.019 (0.030)	0.514 [0.825]	0.038	0.013 (0.027)	0.636 [0.636]	0.406
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Science-related career aspirations (index)	–0.045	0.106*** (0.037)	0.004 [0.007]	0.046	0.068* (0.035)	0.055 [0.071]	0.410
Some jobs in science are interesting	0.961	0.012** (0.005)	0.029 [0.059]	0.940	0.026*** (0.008)	0.001 [0.005]	0.138
Would consider a job in science	0.721	0.023* (0.013)	0.078 [0.104]	0.762	0.038*** (0.014)	0.006 [0.012]	0.404
Interested in at least one STEM job ^a	0.817	0.002 (0.011)	0.863 [0.863]	0.899	0.003 (0.009)	0.779 [0.779]	0.963
Wage prospects important in career choice (<i>z</i> -score)	–0.043	0.112*** (0.036)	0.002 [0.009]	0.037	0.062* (0.032)	0.055 [0.074]	0.295
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on students’ self-reported science-related career aspirations, separately by grade level and gender. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the synthetic index (highlighted in bold) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values for the individual components of the index are adjusted for multiple testing across the index components, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. ^a The STEM occupations in the list were chemist, computer scientist, engineer, industrial designer, renewable energy technician, and researcher in biology. The non-STEM occupations were lawyer, pharmacist, physician, and psychologist.

Table F6 – Grade 12 Students: Enrolment Status the Following Year (Detailed)

	Grade 12 (science track) students						
	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. STEM undergraduate programs							
<i>All undergraduate STEM majors</i>							
Major: STEM	0.289	0.020 (0.014)	0.139 [0.157]	0.470	−0.002 (0.019)	0.925 [0.926]	0.310
<i>Selective STEM majors</i>							
Maths, physics, engineering, computer science (CPGE)	0.084	0.022** (0.009)	0.019 [0.049]	0.211	0.012 (0.014)	0.397 [0.663]	0.548
Earth and life sciences (CPGE)	0.020	0.007 (0.005)	0.172 [0.272]	0.010	0.001 (0.003)	0.768 [0.769]	0.293
Sciences - vocational (STS)	0.006	0.002 (0.003)	0.519 [0.520]	0.011	−0.005* (0.003)	0.099 [0.247]	0.092
<i>Non-selective STEM majors</i>							
Maths, physics, computer science	0.077	0.010 (0.008)	0.217 [0.272]	0.157	0.006 (0.011)	0.625 [0.769]	0.764
Earth and life sciences	0.103	−0.022** (0.009)	0.019 [0.049]	0.081	−0.016* (0.009)	0.064 [0.247]	0.620
Panel B. Non-STEM undergraduate programs							
<i>All undergraduate non-STEM majors</i>							
Major: non-STEM	0.507	−0.031** (0.016)	0.049	0.293	−0.008 (0.015)	0.571	0.286
<i>Selective non-STEM majors</i>							
Business and economics (CPGE)	0.021	0.001 (0.004)	0.826	0.017	0.006 (0.005)	0.220	0.453
Humanities (CPGE)	0.014	−0.002 (0.003)	0.584	0.003	−0.001 (0.001)	0.439	0.877
Other vocational (STS)	0.011	−0.009*** (0.003)	0.002	0.008	−0.005** (0.002)	0.027	0.306
<i>Non-selective non-STEM majors</i>							
Medicine and pharmacy	0.259	−0.008 (0.016)	0.623	0.108	0.005 (0.011)	0.653	0.506
Law and economics	0.107	−0.006 (0.010)	0.580	0.079	−0.000 (0.008)	0.975	0.677
Humanities and psychology	0.080	−0.008 (0.009)	0.394	0.040	−0.007 (0.006)	0.265	0.924
Sports studies	0.023	−0.003 (0.006)	0.558	0.052	−0.004 (0.009)	0.679	0.982
Not enrolled in higher education	0.206	0.011 (0.013)	0.430	0.237	0.012 (0.015)	0.425	0.957
N		2,827			2,924		

Notes: This table reports estimates of the treatment effects of the role model interventions on science track Grade 12 (science track) students' enrolment outcomes in the academic year following the classroom interventions, i.e. 2016/17, separately by gender. The enrolment outcomes are measured using student-level administrative data. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the treatment effect estimates on the probability of enrolling in a STEM undergraduate major (Panel A) are adjusted for multiple testing across the study's nine main outcomes of interest, separately by gender (see Appendix D for details). The *q*-values associated with the estimates for the different selective and non-selective STEM majors (Panel A) are adjusted for multiple testing across these different STEM majors, separately by gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table F7 – Grade 12 Students: Performance in *Baccalauréat* Exams

	Grade 12 (science track) students						
	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Obtained the Baccalauréat	0.928	−0.014 (0.011)	0.176 [0.264]	0.877	−0.005 (0.010)	0.576 [0.577]	
Baccalauréat percentile rank	53.54	−1.408* (0.780)	0.071 [0.214]	47.72	0.433 (0.760)	0.569 [0.577]	0.057
Baccalauréat percentile rank in maths	46.21	0.476 (0.845)	0.573 [0.574]	47.47	1.385 (0.901)	0.124 [0.373]	0.330
N		2,827			2,924		

Notes: This table reports estimates of the treatment effects of the role model interventions on Grade 12 (science track) students' performance on the *Baccalauréat* exams, separately by gender. The *Baccalauréat* outcomes are measured using student-level administrative data. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values are adjusted for multiple testing across the three *Baccalauréat* outcomes, separately by gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

G Robustness Checks

Table G1 – Treatment Effects on Student Perceptions: Estimates without Controlling for Baseline Characteristics

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
Positive perceptions of science-related careers (index)	−0.020	0.245*** (0.028)	0.000 [0.001]	0.023	0.167*** (0.029)	0.000 [0.001]	0.026
More men in science-related jobs	0.628	0.156*** (0.013)	0.000 [0.001]	0.629	0.168*** (0.014)	0.000 [0.001]	0.455
Equal gender aptitude for maths (index)	0.115	0.109*** (0.025)	0.000 [0.001]	−0.134	0.148*** (0.030)	0.000 [0.001]	0.273
Women don't really like science	0.157	0.059*** (0.011)	0.000 [0.001]	0.198	0.103*** (0.013)	0.000 [0.001]	0.003
W face discrimination in science-related jobs	0.603	0.127*** (0.013)	0.000 [0.001]	0.527	0.153*** (0.014)	0.000 [0.001]	0.123
Taste for science subjects (index)	−0.169	−0.038 (0.036)	0.294 [0.442]	0.197	−0.019 (0.031)	0.533 [0.685]	0.627
Self-concept in maths (index)	−0.198	−0.008 (0.031)	0.806 [0.807]	0.231	0.039 (0.032)	0.217 [0.326]	0.225
Science-related careers aspirations (index)	−0.103	0.012 (0.030)	0.695 [0.807]	0.120	0.007 (0.029)	0.801 [0.902]	0.906
N		6,475			5,751		
Panel B. Grade 12 (science track)							
Positive perceptions of science-related careers (index)	−0.003	0.312*** (0.034)	0.000 [0.001]	0.003	0.155*** (0.033)	0.000 [0.001]	0.000
More men in science-related jobs	0.712	0.125*** (0.016)	0.000 [0.001]	0.717	0.149*** (0.015)	0.000 [0.001]	0.209
Equal gender aptitude for maths (index)	0.158	0.095*** (0.028)	0.001 [0.002]	−0.161	0.132*** (0.040)	0.001 [0.002]	0.447
Women don't really like science	0.074	0.044*** (0.009)	0.000 [0.001]	0.146	0.073*** (0.015)	0.000 [0.001]	0.089
W face discrimination in science-related jobs	0.624	0.095*** (0.020)	0.000 [0.001]	0.600	0.072*** (0.018)	0.000 [0.001]	0.344
Taste for science subjects (index)	−0.002	0.016 (0.034)	0.632 [0.633]	0.002	−0.000 (0.039)	0.998 [0.999]	0.721
Self-concept in maths (index)	−0.184	0.050 (0.039)	0.202 [0.228]	0.187	0.072** (0.035)	0.041 [0.062]	0.634
Science-related careers aspirations (index)	−0.045	0.113*** (0.037)	0.002 [0.003]	0.046	0.050 (0.033)	0.131 [0.169]	0.161
N		2,600			2,636		

Notes: This table reports estimates of the treatment effects of the role model interventions on students' perceptions, separately by grade level and gender, and without controlling for students' baseline characteristics. The sample is restricted to students who completed the post-intervention questionnaire. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression controls for school fixed effects to account for the fact that randomization was stratified by school. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values are adjusted for multiple testing across the study's nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table G2 – Treatment Effects on Enrolment Outcomes: Estimates without Controlling for Baseline Characteristics

	Girls			Boys			<i>p</i> -value of diff. (5)–(2) (7)
	Control group mean (1)	Treatment effect (LATE) (2)	<i>p</i> -value [<i>q</i> -value] (3)	Control group mean (4)	Treatment effect (LATE) (5)	<i>p</i> -value [<i>q</i> -value] (6)	
Panel A. Grade 10							
All STEM tracks							
Grade 11: Science track	0.355	−0.004 (0.014)	0.753 [0.807]	0.551	−0.002 (0.015)	0.910 [0.910]	0.876
General vs. technical STEM track							
Grade 11: Science - general track	0.328	0.001 (0.013)	0.942 [0.942]	0.416	0.007 (0.014)	0.613 [0.614]	0.699
Grade 11: Science - technical track	0.026	−0.005 (0.003)	0.128 [0.256]	0.135	−0.009 (0.008)	0.300 [0.601]	0.693
N		7,241			6,459		
Panel B. Grade 12 (science track)							
All undergraduate STEM majors							
Major: STEM	0.289	0.024* (0.014)	0.080 [0.103]	0.470	0.003 (0.020)	0.886 [0.998]	0.332
Selective vs. non-selective STEM							
Major: selective STEM	0.110	0.035*** (0.011)	0.002 [0.004]	0.232	0.020 (0.016)	0.200 [0.283]	0.387
Major: non-selective STEM	0.178	−0.011 (0.011)	0.322 [0.322]	0.239	−0.017 (0.014)	0.212 [0.283]	0.745
Male- vs. female-dominated STEM							
Major: male-dominated STEM (maths, physics, computer science)	0.166	0.038*** (0.012)	0.002 [0.004]	0.379	0.017 (0.019)	0.387 [0.388]	0.287
Major: female-dominated STEM (earth and life sciences)	0.123	−0.015 (0.010)	0.158 [0.211]	0.091	−0.014 (0.009)	0.119 [0.283]	0.952
N		2,827			2,924		

Notes: This table reports estimates of the treatment effects of the role model interventions on students’ enrolment outcomes in the academic year following the classroom interventions, i.e. 2016/17, separately by grade level and gender, and without controlling for student baseline characteristics. The enrolment outcomes are measured using student-level administrative data. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 4 report the average value for students in the control group. Columns 2 and 5 report the local average treatment effect (LATE) estimates. They are obtained from a regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression controls for school fixed effects to account for the fact that randomization was stratified by school. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report the cluster-robust *p*-value of the estimated treatment effect and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). The *q*-values associated with the treatment effect estimates on “Grade 11: Science track” (Panel A) and “Major: STEM” (Panel B) are adjusted for multiple testing across the study’s nine main outcomes of interest, separately by grade level and gender (see Appendix D for details). The *q*-values associated with the treatment effect estimates for the different STEM tracks (Panel A) or the different STEM majors (Panel B) are adjusted for multiple testing across these different STEM tracks or majors, separately by grade level and gender. The *p*-value of the difference between the treatment effects by gender is reported in column 7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

H Randomization Inference

This appendix evaluates the robustness of our results to computing p -values using non-parametric randomization inference tests rather than model-based cluster-robust inference.

Randomization inference, which was first proposed by Fisher (1935) and was later developed by Rosenbaum (2002), has been used in a number of recent RCT studies in economics and political science as an alternative to model-based inference. The intuition behind this approach is relatively straightforward. In RCTs, researchers know exactly how the randomization was performed. Randomization inference uses this knowledge to assess whether observed outcomes in a given sample are likely to have occurred by chance even if the treatment had no effect. This can be obtained numerically through Monte Carlo methods, by computing the treatment effects for varying random draws of the treatment assignment, whose data-generating process is known. This test is non-parametric since it does not make distributional assumptions.^{A.5}

In our setting, the ITT effect under the observed assignment to treatment is estimated using the following reduced-form specification:

$$Y_{ics} = \alpha + \beta T_{cs} + \mathbf{X}_{ics}\pi + \theta_s + \epsilon_{ics}, \quad (\text{A.1})$$

where Y_{ics} is the observed outcome of student i in class c and school s , T_{cs} the observed treatment assignment of the student's class, \mathbf{X}_{ics} the student characteristics in Table 1, and θ_s the school fixed effects. The ITT estimate under the observed treatment assignment is denoted by $\hat{\beta}$.

To conduct randomization inference, we proceed as follows. Taking into account the fact that randomization was stratified by school and grade level, we first re-assign treatment $R=2,000$ times among participating classes using the exact same stratified procedure.^{A.6} Let $\{P^r\}_{r=1}^R$ denote the set of R random placebo assignments from the randomization process. We then re-estimate the ITT effects of these placebo treatments using the following reduced-form specification, which is estimated separately by grade level and gender:

$$Y_{ics} = \alpha_r + \beta_r P_{cs}^r + \mathbf{X}_{ics}\pi_r + \lambda_s + \eta_{ics}, \quad r = 1, \dots, R, \quad (\text{A.2})$$

where P_{cs}^r indicates assignment to a placebo treatment group for random draw r . School fixed effects, λ_s , are included to account for the fact that the randomization is stratified by school.

Since P_r is a randomly generated placebo, $\mathbb{E}(\beta_r) = 0$. Let $F(\hat{\beta}_r)$ denote the empirical c.d.f. of all elements of $\{P_r\}_{r=1}^R$. We test the null hypothesis that the program had no effect on outcome Y by checking if the ITT estimate that we obtain for the observed treatment assignment is in the tails of the distribution of placebo treatments. We can reject $H_0: \hat{\beta} = 0$ with a confidence level of $1 - \alpha$ if $\hat{\beta} \leq F^{-1}\left(\frac{\alpha}{2}\right)$ or $\hat{\beta} \geq F^{-1}\left(1 - \frac{\alpha}{2}\right)$. Since the placebo assignments only vary across randomization units (here classes), this method accounts for correlation within units. Following Davison and Hinkley (1997), we compute the p -values from a two-sided randomization inference test of zero treatment effects as $p = (1 + \sum_{r=1}^R \mathbb{1}(|\hat{\beta}_r| \geq |\beta|)) / (1 + R)$.

Table H1 presents the results of randomization inference tests of the hypotheses that the role model interventions had no effect on student perceptions and enrolment outcomes, separately by grade level and gender. The ITT estimates $\hat{\beta}$ are shown in columns 1 and 4. The cluster-robust model-based p -values are reported in columns 2 and 5, while those based on randomization inference are in columns 3 and 6. The results of the randomization inference tests yield p -values that are generally close to the cluster-robust model-based p -values. Although they tend to be slightly more conservative, they confirm the program's statistically significant effects on enrolment in selective and male-dominated STEM programs for girls in Grade 12.

^{A.5}For more details on randomization inference, see Rosenbaum (2010) and Imbens and Rubin (2015).

^{A.6}See Paz and West (2019) for the number of draws to be used.

Table H1 – Randomization Inference for Intention-to-Treat Estimates

	Girls			Boys		
	ITT	<i>p</i> -value: model- based	<i>p</i> -value: rand. inference	ITT	<i>p</i> -value: model- based	<i>p</i> -value: rand. inference
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Grade 10						
<i>Student perceptions</i>						
Positive perceptions of science-related careers (index)	0.227	0.000	0.000	0.151	0.000	0.000
More men in science-related jobs	0.143	0.000	0.000	0.158	0.000	0.000
Equal gender aptitude for maths (index)	0.103	0.000	0.000	0.132	0.000	0.000
Women don't really like science	0.052	0.000	0.000	0.094	0.000	0.000
Women face discrimination in science-related jobs	0.116	0.000	0.000	0.143	0.000	0.000
Taste for science subjects (index)	-0.031	0.280	0.320	-0.019	0.436	0.500
Self-concept in maths (index)	-0.001	0.981	0.980	0.031	0.255	0.320
Science-related career aspirations (index)	0.005	0.852	0.870	0.004	0.873	0.880
<i>Enrolment outcomes</i>						
Grade 11: Science track	-0.002	0.863	0.880	-0.005	0.643	0.690
Grade 11: Science - general track	0.003	0.796	0.810	0.004	0.713	0.740
Grade 11: Science - technical track	-0.004	0.193	0.270	-0.009	0.240	0.300
N	7,241			6,459		
Panel B. Grade 12 (science track)						
<i>Student perceptions</i>						
Positive perceptions of science-related careers (index)	0.279	0.000	0.000	0.160	0.000	0.000
More men in science-related jobs	0.115	0.000	0.000	0.140	0.000	0.000
Equal gender aptitude for maths (index)	0.074	0.007	0.050	0.117	0.004	0.030
Women don't really like science	0.039	0.000	0.000	0.069	0.000	0.000
Women face discrimination in science-related jobs	0.080	0.000	0.000	0.070	0.000	0.000
Taste for science subjects (index)	0.017	0.592	0.710	0.013	0.738	0.810
Self-concept in maths (index)	0.048	0.150	0.300	0.064	0.042	0.140
Science-related career aspirations (index)	0.100	0.005	0.040	0.064	0.061	0.160
<i>Enrolment outcomes</i>						
Undergraduate major: STEM	0.019	0.154	0.310	-0.002	0.927	0.950
Undergraduate major: selective STEM	0.029	0.008	0.050	0.008	0.583	0.690
Undergraduate major: non-selective STEM	-0.010	0.341	0.510	-0.010	0.456	0.570
Undergraduate major: male-dominated STEM	0.031	0.005	0.030	0.012	0.495	0.610
Undergraduate major: female-dominated STEM	-0.014	0.175	0.350	-0.014	0.129	0.270
N	2,827			2,924		

Notes: This table presents the results of randomization inference tests of the hypotheses that the program had no effect on student perceptions and enrolment outcomes. We randomly re-assign treatment 2,000 times among participating classes within each school and grade level, and re-estimate the ITT effects of these placebo treatments. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1 in the main text. The ITT estimates under the observed assignment are reported in columns 1 and 4 separately by gender. The associated cluster-robust model-based *p*-values are shown in columns 2 and 5. The randomization inference *p*-values are reported in columns 3 and 6. They are computed from a two-sided randomization inference test of zero treatment effects as $p = \left(1 + \sum_{r=1}^R \mathbb{1}(|\hat{\beta}_r| \geq |\hat{\beta}|)\right) / (1 + R)$, where $\{\hat{\beta}_r\}_{r=1}^R$ is the set of *R* placebo ITT estimates, $\hat{\beta}$ is the ITT estimate under the observed assignment, and $\mathbb{1}(\cdot)$ is the indicator function.

I Information, Persistence, Timing: Additional Results

I.1 Intensity of Information Provision

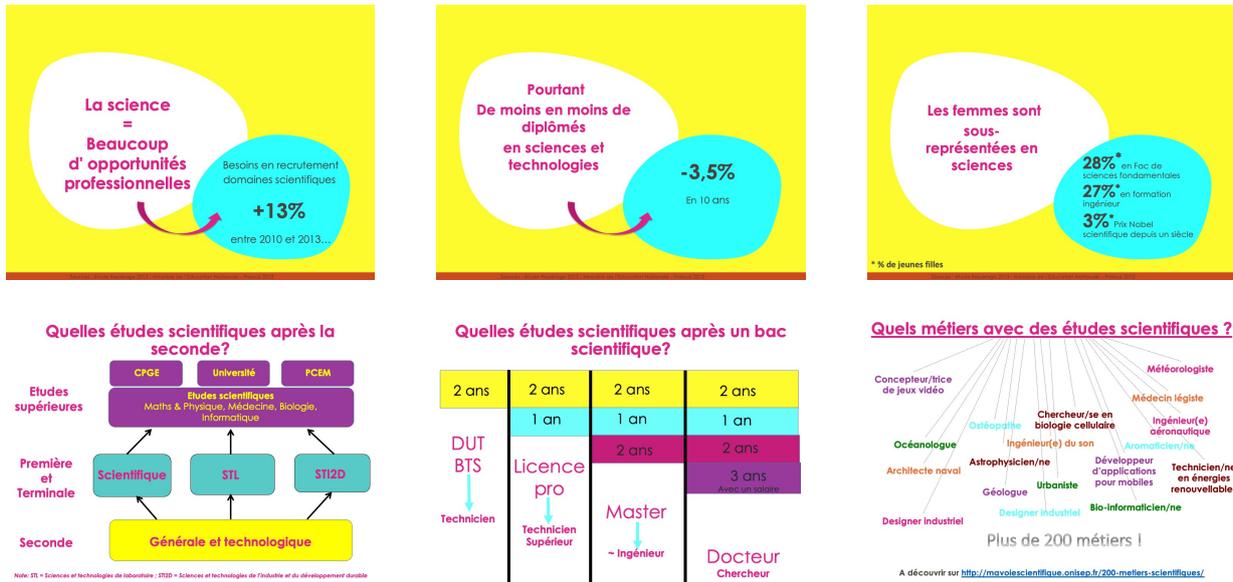


Figure I1 – Screenshots of the Slides Providing General Information on STEM Careers (“Regular Slides”)

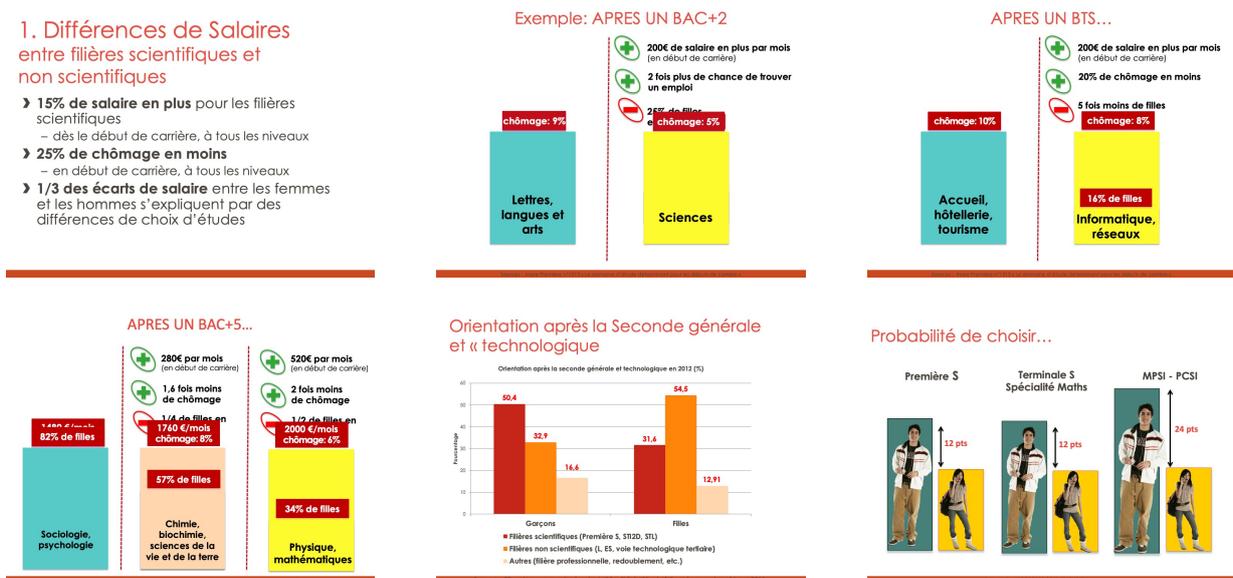


Figure I2 – Screenshots of the Additional Slides Providing General Information on STEM Careers (“Augmented Slides”)

Table I1 – Balancing Test: Classrooms Assigned to Role Models who were Provided with the Regular vs. Augmented Sets of Slides

	Set of slides		Difference (2)–(1) (3)	<i>p</i> -value of diff. (4)
	Regular (1)	Augmented (2)		
Panel A. Grade 10				
<i>Student characteristics</i>				
Female	0.532	0.526	–0.006	0.651
Age (years)	15.10	15.14	0.04	0.002
Non-French	0.052	0.067	0.015	0.014
High SES	0.396	0.369	–0.027	0.193
Medium-high SES	0.136	0.122	–0.014	0.059
Medium-low SES	0.238	0.244	0.006	0.559
Low SES	0.229	0.265	0.035	0.030
Number of siblings	1.467	1.500	0.033	0.383
Class size	33.86	32.76	–1.10	0.000
At least one science elective course	0.387	0.399	0.012	0.722
At least one standard elective course	0.746	0.759	0.012	0.648
DNB percentile rank in maths	58.37	58.57	0.20	0.886
DNB percentile rank in French	56.79	58.69	1.90	0.122
<i>Predicted track in Grade 11</i>				
Grade 11: Science track	0.443	0.457	0.014	0.248
Grade 11: Science - general track	0.366	0.380	0.014	0.326
Grade 11: Science - technical track	0.077	0.077	0.000	0.923
N	6,047	7,653	13,700	
Panel B. Grade 12 (science track)				
<i>Student characteristics</i>				
Female	0.491	0.492	0.001	0.951
Age (years)	17.12	17.13	0.01	0.673
Non-French	0.044	0.057	0.014	0.133
High SES	0.475	0.453	–0.022	0.519
Medium-high SES	0.140	0.132	–0.008	0.517
Medium-low SES	0.209	0.208	–0.001	0.936
Low SES	0.176	0.207	0.031	0.197
Number of siblings	1.479	1.516	0.037	0.454
Class size	32.13	31.83	–0.29	0.602
DNB percentile rank in maths	74.19	73.94	–0.25	0.870
DNB percentile rank in French	69.45	69.75	0.30	0.843
<i>Predicted undergraduate major</i>				
Major: STEM	0.384	0.382	–0.002	0.735
Major: selective STEM	0.179	0.175	–0.004	0.684
Major: male-dominated STEM	0.276	0.274	–0.001	0.856
N	2,748	3,003	5,751	

Notes: Each row corresponds to a different linear regression with the dependent variable listed on the left for students enrolled in Grade 10 in 2015/16 (Panel A) and in Grade 12 (Panel B). Columns 1 and 2 show the average value for students whose high school was visited by a role model provided with the regular or augmented set of slides, respectively. Column 3 reports the coefficient from the regression of each variable on an indicator that takes the value one if the school was visited by a role model who received the augmented slides and zero if the school was visited by a role model who received the regular slides, with the *p*-value reported in column 4. Standard errors are adjusted for clustering at the class level. High school tracks in Grade 11 are predicted for each student using the coefficients from a linear regression of the corresponding binary variable (e.g. enrolment in the general science track) on all the student characteristics listed in the table. This model is fitted on the sample of students in the control group.

Table I2 – Treatment Effects (ITT) for Grade 12 Students: Regular vs. Augmented Slides

	Girls (1)	Boys (2)
Major: STEM		
Treatment group indicator (T)	0.024 (0.023)	-0.021 (0.029)
T^* Augmented slides	-0.006 (0.037)	0.029 (0.040)
Major: selective STEM		
Treatment group indicator (T)	0.038*** (0.014)	0.021 (0.024)
T^* Augmented slides	-0.016 (0.021)	-0.018 (0.035)
Major: male-dominated STEM		
Treatment group indicator (T)	0.048** (0.019)	-0.003 (0.030)
T^* Augmented slides	-0.025 (0.026)	0.020 (0.039)
Science-related jobs pay higher wages		
Treatment group indicator (T)	0.012 (0.032)	0.056*** (0.021)
T^* Augmented slides	0.087* (0.049)	-0.055 (0.036)
Positive perceptions of science-related careers (index)		
Treatment group indicator (T)	0.312*** (0.057)	0.173*** (0.052)
T^* Augmented slides	-0.042 (0.082)	-0.058 (0.088)
Equal gender aptitude for maths (index)		
Treatment group indicator (T)	0.116*** (0.041)	0.046 (0.061)
T^* Augmented slides	-0.056 (0.070)	0.131 (0.103)
N	2,827	2,924

Notes: This table reports estimates of the treatment effects (ITT) of the role model interventions on student outcomes for Grade 12 students, separately by gender and by the type of slides (regular or augmented) that were provided to the female role model who visited the classroom. For each outcome of interest, the reported coefficients are obtained from a regression of the outcome on a treatment group indicator (T) and the interaction between this indicator and an indicator that takes the value one if the role model was provided with the augmented set of slides. The specification includes school fixed effects (to account for the fact that randomization was stratified by school), month-of-visit fixed effects interacted with the treatment group indicator (to account for the fact that the additional slides were provided slightly later in the experiment), and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

I.2 Persistence of the Effects and Timing of Visits

Table I3 – Persistence of Effects on Student Perceptions

	Girls			Boys		
	Days since intervention		<i>p</i> -value of diff. (3)	Days since intervention		<i>p</i> -value of diff. (6)
	≤63 days (1)	>63 days (2)		≤63 days (4)	>63 days (5)	
Panel A. Grade 10						
Positive perceptions of science-related careers (index)	0.289*** (0.037)	0.200*** (0.038)	0.083	0.162*** (0.037)	0.162*** (0.039)	0.999
More men in science-related jobs	0.146*** (0.016)	0.163*** (0.019)	0.479	0.188*** (0.019)	0.149*** (0.019)	0.138
Equal gender aptitude for maths (index)	0.143*** (0.031)	0.078** (0.037)	0.182	0.173*** (0.041)	0.108*** (0.042)	0.258
Women don't really like science	0.080*** (0.015)	0.031** (0.015)	0.022	0.114*** (0.016)	0.087*** (0.020)	0.292
W face discrimination in science-related jobs	0.139*** (0.017)	0.112*** (0.018)	0.262	0.165*** (0.018)	0.142*** (0.020)	0.379
Taste for science subjects (index)	-0.000 (0.045)	-0.068* (0.040)	0.254	-0.028 (0.036)	-0.013 (0.037)	0.775
Self-concept in maths (index)	-0.050 (0.036)	0.051 (0.042)	0.063	-0.039 (0.042)	0.112*** (0.035)	0.005
Science-related career aspirations (index)	0.006 (0.038)	0.005 (0.042)	0.983	-0.023 (0.036)	0.035 (0.039)	0.274
N	3,119	3,356		2,856	2,895	
Panel B. Grade 12 (science track)						
Positive perceptions of science-related careers (index)	0.349*** (0.044)	0.249*** (0.044)	0.108	0.217*** (0.049)	0.125*** (0.043)	0.157
More men in science-related jobs	0.125*** (0.021)	0.120*** (0.023)	0.867	0.130*** (0.017)	0.167*** (0.026)	0.235
Equal gender aptitude for maths (index)	0.090** (0.045)	0.068** (0.032)	0.696	0.090 (0.059)	0.158*** (0.060)	0.420
Women don't really like science	0.072*** (0.015)	0.015 (0.011)	0.003	0.080*** (0.022)	0.067*** (0.021)	0.697
W face discrimination in science-related jobs	0.105*** (0.024)	0.068** (0.030)	0.345	0.112*** (0.023)	0.038 (0.027)	0.038
Taste for science subjects (index)	-0.073 (0.049)	0.100** (0.044)	0.010	0.048 (0.056)	-0.019 (0.057)	0.398
Self-concept in maths (index)	0.075 (0.049)	0.030 (0.049)	0.512	0.046 (0.037)	0.089* (0.053)	0.504
Science-related career aspirations (index)	-0.021 (0.056)	0.221*** (0.041)	0.000	0.115*** (0.042)	0.022 (0.056)	0.182
N	1,201	1,399		1,255	1,381	

Notes: This table reports estimates of the treatment effects of the role model interventions on student perceptions, separately by grade level, gender, and by the number of days between the date of the classroom visit and the date when students completed the survey. The sample is split at the median of this time interval, i.e. 63 days. On average, students below this threshold completed the survey 46 days after the intervention while those above completed it 93 days after, i.e. an additional 47 days. The sample is restricted to students who completed the post-intervention questionnaire. Each coefficient is obtained from a linear regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). The *p*-value of the difference between the treatment effects for students who took the before/after the 63 days threshold since the intervention is reported in columns 3 and 6, separately by gender. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table I4 – Effects on Enrolment Outcomes by Timing of Classroom Visits: Grade 12 Students

	Girls			Boys		
	Month of visit		<i>p</i> -value of diff. (3)	Month of visit		<i>p</i> -value of diff. (6)
	Nov-Dec 2015 (1)	Jan-Feb 2016 (2)		Nov-Dec 2015 (4)	Jan-Feb 2016 (5)	
Major: STEM	0.038* (0.020)	0.003 (0.019)	0.210	0.054 (0.037)	−0.029 (0.022)	0.053
Major: selective STEM	0.046** (0.019)	0.019 (0.015)	0.266	0.030 (0.028)	−0.002 (0.017)	0.324
Major: male-dominated STEM	0.038** (0.018)	0.024 (0.016)	0.548	0.058 (0.035)	−0.011 (0.021)	0.098
N	1,253	1,461		1,257	1,575	

Notes: This table reports estimates of the treatment effects of the role model interventions on the enrolment outcomes of Grade 12 students in the year following high school graduation, i.e. 2016/17, separately by gender and by whether the classroom visit took place before or after 31 December 2015. The enrolment outcomes are measured using student-level administrative data. Each coefficient is obtained from a linear regression of the outcome of interest on a classroom visit indicator, using treatment assignment as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). The *p*-value of the difference between the treatment effects for classroom visits that took place before vs. after 31 December 2015, is reported in columns 3 and 6, separately by gender. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

J Spillover Effects

This appendix investigates whether the program could have had spillover effects for students who were not exposed to the role model interventions in participating schools. Section J.1 provides survey evidence suggesting that the scope for spillover effects was relatively limited. Section J.2 describes the difference-in-differences (DiD) approach that we use to estimate the magnitude of spillovers, the results of which point to non-statistically significant effects.

J.1 Survey Evidence

To get some sense of the scope for spillover effects in the context of our study, we included in the last section of the survey a series of questions asking students in the treatment group whether they had talked about the classroom interventions with their classmates, with schoolmates from other classes, or with friends from other schools. We also asked students in the control group whether they had heard about a science-related awareness-raising program and, more specifically, whether they knew about other classes in the school being visited by a female or male scientist.

Overall, the summary statistics from the survey data suggest relatively limited opportunities for spillover effects (see Table J1). In the treatment group, 58% of Grade 10 students and 63% of science track Grade 12 students report having talked about the classroom intervention with their classmates, but only 24% (27%) with schoolmates from other classes, and 20% with students from other schools. Interestingly, these proportions are higher for girls than for boys: in Grade 10, 66% of girls in the treatment group report having discussed the program with their classmates and 28% with schoolmates from other classes vs. respectively 50% and 20% among boys; in Grade 12, 70% of girls in the treatment group report having discussed the program with their classmates and 33% with schoolmates from other classes vs. respectively 56% and 21% among boys.

In the control group, only 14% of students in Grade 10 report having heard of classroom visits in other classes, mostly in a vague manner (12%). In Grade 12, students in the control group are more likely to report being at least vaguely aware of such visits (34%), but less than 5% of boys and girls have a precise recollection. Gender differences in these proportions are small and barely statistically significant. The fact that students in Grade 12 are more likely to report being aware of classroom visits could be at least partly due to the fact that the share of students assigned to the treatment group among all students from the same grade level was typically larger in Grade 12 than in Grade 10, on average 32% vs. 25%. Despite these differences, the overall picture that emerges from the survey is that students in the control group had only limited awareness of the classroom interventions in other classes.

J.2 Differences-in-Differences Estimates of Spillover Effects

We complement the survey evidence by investigating more formally whether the role model interventions could have affected the higher education choices of Grade 12 students whose classes were not assigned to the treatment group. These students are either in the classes that were not selected by school principals to participate in the program evaluation or in the participating classes that were randomly assigned to the control group.

Our experimental design does not include a “super control” group composed of students enrolled in schools randomly chosen to have zero probability of assignment to the treatment among the classes selected by school principals. Spillover effects cannot, therefore, be identified by comparing the control group classes in participating schools with such supercontrol group classes, as in the design pioneered by Duflo and Saez (2003).^{A.7} Instead, our approach builds on

^{A.7}Vazquez-Bare (forthcoming) develops a potential-outcome-based non-parametric framework to identify

the following intuition: for schools that participated in the evaluation, the random assignment of treatment to participating classes makes it possible to estimate the average outcome that would have been observed if *all* students from these schools had only been exposed to the spillover effects of role model interventions, without being *directly* exposed to a female role model. This unobserved “spillover-only” counterfactual can be estimated at the school level using an appropriately weighted average of non-treated classes: it suffices to compute the weighted average outcome of students in the non-participating classes and in the participating classes that were randomly assigned to the control group, with respective weights equal to the share of participating and of non-participating classes in the school. Average spillover effects can then be estimated by comparing this “spillover-only” counterfactual to a “no-treatment” counterfactual. This second counterfactual is constructed under the assumption that absent treatment, mean outcomes in participating school would have followed the same evolution as in non-participating schools. Having verified that this common trends assumption is satisfied in the pre-treatment period 2012–2014, we implement a difference-in-differences estimator that identifies the difference between the “spillover-only” and the “no-treatment” counterfactuals. This approach, which is graphically illustrated in Figure J1, enables us to estimate the average spillover effects of role model interventions in the participating schools.

Notations. We are interested in measuring the spillover effects of classroom visits. We denote by D_s a binary indicator for a student’s school s being visited by a female role model and by D_{cs} a binary indicator for a role model intervention taking place in the student’s class c . We consider two time periods, represented by a binary indicator $T \in \{0, 1\}$, with classroom visits taking place in period 1 only. For a given realization of the treatment assignment (d_s, d_{cs}) , the potential outcome for student i in school s , class c , and time t is denoted by $Y_{icst}(d_s, d_{cs})$.

We use the binary indicator G_s to indicate whether school s participated in the experiment and we denote the sets of participating and non-participating schools by \mathcal{S}_1 and \mathcal{S}_0 , respectively. The number of participating (non-participating) schools is denoted by M_1 (M_0). Only a subset of the classes in participating schools were (non-randomly) selected by the principals to participate in the experiment in period 1. The participation status of class c in school s is denoted by the binary indicator G_{cs} . Among participating classes ($G_{cs} = 1$), the binary indicator R_{cs} indicates whether the class was randomly assigned to the treatment group ($R_{cs} = 1$) or to the control group ($R_{cs} = 0$). The experimental setting therefore implies that $D_s = G_s \times T$ and $D_{cs} = R_{cs} \times T$. A student’s observed outcome can then be written

$$Y_{icst} = D_s \cdot D_{cs} \cdot Y_{icst}(1, 1) + D_s \cdot (1 - D_{cs}) \cdot Y_{icst}(1, 0) + (1 - D_s) \cdot Y_{icst}(0, 0). \quad (\text{A.3})$$

To simplify notation, we assume that each school has the same number of students, N , and that the number of students is the same in both periods.

Let $\bar{Y}_{s,t}(0, 0)$ denote the average *potential* outcome of students in school s and year t under no treatment. This average potential outcome corresponds to the case in which no student from school s in year t is exposed to either the direct or spillover effects of classroom visits, i.e.

$$\bar{Y}_{s,t}(0, 0) = \frac{1}{N} \sum_{i=1}^N Y_{icst}(0, 0). \quad (\text{A.4})$$

Let $\bar{Y}_{s,t}(1, 0)$ denote the average *potential* outcome of students in school s and year t in the (non-feasible) scenario in which all students in school s are only exposed to the spillover effects

spillover effects in randomized experiments where units are clustered, without requiring a specific experimental design. This approach, however, cannot be easily adapted to our setting since it requires that the treatment is assigned at the individual level within clusters (schools), not at the group level (classes), in order to exploit variation in all the possible configurations of own and neighbours’ observed treatment assignments.

of role model interventions in other classes, without themselves being visited by a female role model. This “spillover-only” average potential outcome is defined as follows:

$$\bar{Y}_{s,t}(1,0) = \frac{1}{N} \sum_{i=1}^N Y_{icst}(1,0). \quad (\text{A.5})$$

Our parameter of interest is the expected average spillover effect of classroom visits for the students in participating schools in period 1, i.e.

$$\Delta = \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(1,0) - \bar{Y}_{s,1}(0,0)) \right). \quad (\text{A.6})$$

This parameter can be interpreted as the average effect for students in participating schools of being only exposed to the indirect effects of classroom visits compared to the counterfactual of no classroom visit in the school.

Identification of spillover effects. Let $\bar{Y}_{s,t}$ denote the mean *observed* outcome for students in school s and year t , i.e.

$$\bar{Y}_{s,t} = \frac{1}{N} \sum_{i=1}^N Y_{icst}. \quad (\text{A.7})$$

For non-participating schools in periods 0 and 1 and for participating schools in period 0, this mean observed outcome is in expectation equal to the expected average potential outcome under no treatment. Indeed, Equations (A.3), (A.4), and (A.7) imply that

$$\mathbb{E}(\bar{Y}_{s,t}) = \mathbb{E}(\bar{Y}_{s,t}(0,0)) \text{ if } s \in \mathcal{S}_0 \text{ and } t \in \{0,1\} \text{ or if } s \in \mathcal{S}_1 \text{ and } t = 0. \quad (\text{A.8})$$

For each school $s \in \mathcal{S}_1$ that participated in the evaluation, we consider the following partition of students in period 1: let \mathcal{C}_s^0 , \mathcal{C}_s^C , and \mathcal{C}_s^T denote respectively (i) the students in the classes that did not participate in the evaluation ($G_s = 0$), (ii) the students in the participating classes that were randomly assigned to the control group ($G_s = 1$ and $R_{cs} = 0$), and (iii) the students in the participating classes that were randomly assigned to the treatment group ($G_s = 1$ and $R_{cs} = 1$). By definition, the number of students in each group, which we denote by N_s^0 , N_s^C and N_s^T , respectively, is such that $N = N_s^0 + N_s^C + N_s^T$.

For the purpose of estimating spillover effects, we construct a mean counterfactual outcome for participating schools in period 1, which we denote by $\tilde{Y}_{s,1}$. As shown in Proposition 1 below, the expected value of $\tilde{Y}_{s,1}$ coincides with the expected average potential outcome of students in school s and period 1, had all of its students only been exposed to the spillover effects of classroom visits in other classes, without being themselves directly exposed to a female role model. This counterfactual outcome ignores classes in the treatment group and is defined as a weighted average of the observed outcomes of students in the non-participating classes and the control group classes (see Figure J1):

$$\tilde{Y}_{s,1} = \frac{1}{N} \left(\sum_{i \in \mathcal{C}_s^0} Y_{ics1} + \left(1 + \frac{N_s^T}{N_s^C} \right) \sum_{i \in \mathcal{C}_s^C} Y_{ics1} \right), \quad s \in \mathcal{S}_1. \quad (\text{A.9})$$

The intuition is as follows. The “spillover only” counterfactual measured at the school level cannot be recovered from the non-participating classes only, since these classes were not randomly selected by school principals. However, having noted that the mean observed outcome of students in the control group is an unbiased estimator of the mean (unobserved)

“spillover-only” outcome for students in the treatment group, one can reconstruct the school-level “spillover-only” counterfactual by restricting the set of students to those in non-participating classes and control group classes. To estimate the mean outcome that would have been observed if all students had only been exposed to the spillover effects of classroom visits, it suffices to reweight students in the control group so that they match the total number of students in the participating classes (i.e. treatment and control), and then combine this reweighted sample with the sample of students in non-participating classes to compute the average outcome.

Assumption 1. *Random assignment of treatment to participating classes.*

$$\mathbb{E} \left(\frac{1}{N_s^T} \sum_{i \in \mathcal{C}_s^T} Y_{ics1}(1, 0) \right) = \mathbb{E} \left(\frac{1}{N_s^C} \sum_{i \in \mathcal{C}_s^C} Y_{ics1}(1, 0) \right), \quad s \in \mathcal{S}_1.$$

Assumption 1 states that students in the treatment and control group classes of participating schools have the same expected average potential outcome under the “spillover-only” treatment. Our experimental design ensures that this assumption is satisfied.

Proposition 1. *Under Assumption 1, the counterfactual $\tilde{Y}_{s,1}$ is an unbiased estimator of the expected average potential outcome of students in participating school s and period 1 under the “spillover-only” treatment, $\bar{Y}_{s,1}(1, 0)$:*

$$\mathbb{E}(\tilde{Y}_{s,1}) = \mathbb{E}(\bar{Y}_{s,1}(1, 0)), \quad s \in \mathcal{S}_1.$$

Proof. From the definition of the “spillover-only” counterfactual in Equation (A.9), we have

$$\begin{aligned} \mathbb{E}(\tilde{Y}_{s,1}) &= \mathbb{E} \left(\frac{1}{N} \left(\sum_{i \in \mathcal{C}_s^0} Y_{ics1} + \left(1 + \frac{N_s^T}{N_s^C} \right) \sum_{i \in \mathcal{C}_s^C} Y_{ics1} \right) \right) \\ &= \frac{1}{N} \left(\sum_{i \in \mathcal{C}_s^0} \mathbb{E}(Y_{ics1}(1, 0)) + \sum_{i \in \mathcal{C}_s^C} \mathbb{E}(Y_{ics1}(1, 0)) + \frac{N_s^T}{N_s^C} \sum_{i \in \mathcal{C}_s^C} \mathbb{E}(Y_{ics1}(1, 0)) \right) \\ &= \frac{1}{N} \left(\sum_{i \in \mathcal{C}_s^0} \mathbb{E}(Y_{ics1}(1, 0)) + \sum_{i \in \mathcal{C}_s^C} \mathbb{E}(Y_{ics1}(1, 0)) + \sum_{i \in \mathcal{C}_s^T} \mathbb{E}(Y_{ics1}(1, 0)) \right) \\ &= \frac{1}{N} \sum_{i=1}^N \mathbb{E}(Y_{ics1}(1, 0)) \\ &= \mathbb{E}(\bar{Y}_{s,1}(1, 0)). \end{aligned}$$

The second equality follows from Equation (A.3), the third equality follows from Assumption 1, while the last equality follows from Equation (A.5). The key intuition for this result is that by virtue of the random assignment of treatment to participating classes, the mean observed outcome of students assigned to the control group is an unbiased estimator of the mean unobserved “spillover-only” outcome of students assigned to the treatment group. \square

Identifying spillover effects requires comparing the “spillover-only” counterfactual with the “no-treatment” counterfactual. To this end, we define the following difference-in-differences estimator, which we denote by $\hat{\Delta}$:

$$\hat{\Delta} = \frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\tilde{Y}_{s,1} - \bar{Y}_{s,0}) - \frac{1}{M_0} \sum_{s \in \mathcal{S}_0} (\bar{Y}_{s,1} - \bar{Y}_{s,0}). \quad (\text{A.10})$$

This estimator compares the evolution of the mean outcome of students in participating schools

between period 0 and period 1 (using the “spillover-only” counterfactual for period 1) with the corresponding evolution in non-participating schools.

Assumption 2. *Common trends between participating and non-participating schools.*

$$\mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(0,0) - \bar{Y}_{s,0}(0,0)) \right) = \mathbb{E} \left(\frac{1}{M_0} \sum_{s \in \mathcal{S}_0} (\bar{Y}_{s,1}(0,0) - \bar{Y}_{s,0}(0,0)) \right).$$

Assumption 2 states that in the absence of role model visits to the school, average outcomes in participating and non-participating schools would have followed parallel trends. Although this assumption cannot be directly tested, it can be indirectly assessed by comparing the evolution of mean outcomes in participating and non-participating schools in the pre-intervention period.

Proposition 2. *Under Assumptions 1 and 2, $\hat{\Delta}$ is an unbiased estimator of the average spillover effect, Δ :*

$$\mathbb{E}(\hat{\Delta}) = \Delta.$$

Proof. From the definition of the difference-in-differences estimator in Equation (A.10), we have

$$\begin{aligned} \mathbb{E}(\hat{\Delta}) &= \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\tilde{Y}_{s,1} - \bar{Y}_{s,0}) - \frac{1}{M_0} \sum_{s \in \mathcal{S}_0} (\bar{Y}_{s,1} - \bar{Y}_{s,0}) \right) \\ &= \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(1,0) - \bar{Y}_{s,0}(0,0)) \right) - \mathbb{E} \left(\frac{1}{M_0} \sum_{s \in \mathcal{S}_0} (\bar{Y}_{s,1}(0,0) - \bar{Y}_{s,0}(0,0)) \right) \\ &= \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(1,0) - \bar{Y}_{s,0}(0,0)) \right) - \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(0,0) - \bar{Y}_{s,0}(0,0)) \right) \\ &= \mathbb{E} \left(\frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\bar{Y}_{s,1}(1,0) - \bar{Y}_{s,1}(0,0)) \right) \\ &= \Delta. \end{aligned}$$

The second equality follows from Equation (A.8) and from Proposition 1, the third equality follows from Assumption 2 (common trends between participating and non-participating schools), while the last equality follows from Equation (A.6). \square

Empirical specification. In the context of our study, the spillover effects estimator (A.10) can be conveniently implemented using a difference-in-differences regression specification. We apply this estimator to investigate whether the classroom interventions affected the college decisions of science track Grade 12 students whose classes were not visited by a female role model.

In our empirical application, we consider the four cohorts of Grade 12 students that were enrolled in the high schools of the Paris region in the year of the intervention (2015) and in the three preceding years (2012, 2013, and 2014).

One complication is that the “For Girls in Science” program was first implemented on a small scale in 2014, i.e. one year before the evaluation was conducted. As a result, some of the schools that participated in the program evaluation in 2015, as well as some of the schools that did not participate in the evaluation, could have been visited by female role models in 2014. Although we cannot precisely identify these schools, the contamination effect is likely to be small since the interventions were carried out by a small number of role models and were not specifically targeted at students enrolled in Grade 10 and Grade 12 (science track). Nonetheless, to ensure

that our difference-in-differences estimates are not biased due to these prior interventions, we use 2012 as the reference year. The baseline differences between participating and non-participating schools are therefore measured at a point in time in which the program was not in place.

Let $\bar{Y}_{s,t}$ denote the average outcome of Grade 12 students in school s and year t . For each participating school $s \in \mathcal{S}_1$, we use Equation (A.9) to construct the “spillover-only” mean counterfactual outcome in 2015, which we denote by $\tilde{Y}_{s,t}$. Our dependent variable, denoted by $\bar{Y}_{s,t}^*$, is then defined as follows:

$$\bar{Y}_{s,t}^* = \begin{cases} \tilde{Y}_{s,t} & \text{if } s \in \mathcal{S}_1 \text{ and } t = 2015 \\ \bar{Y}_{s,t} & \text{otherwise} \end{cases}$$

The spillover effects of classroom visits are then estimated using the following difference-in-differences regression model:

$$\bar{Y}_{s,t}^* = \alpha + \theta_s + \theta_t + \sum_{k=2013}^{2015} \beta_k \cdot \mathbf{1}\{s \in \mathcal{S}_1 \text{ and } t = k\} + \epsilon_{s,t}, \quad (\text{A.11})$$

where θ_s are school fixed effects and θ_t are year fixed effects (using 2012 as the reference year); $\mathbf{1}\{s \in \mathcal{S}_1 \text{ and } t = k\}$ is a dummy variable that takes the value one if the observation corresponds to a participating school observed in year k ; and $\epsilon_{s,t}$ is the error term. Under the common trend assumption, the coefficient $\hat{\beta}_{2015}$ identifies the average spillover effects among the non-treated students in participating schools. The coefficients $\hat{\beta}_{2013}$ and $\hat{\beta}_{2014}$ provide an indirect test of this assumption: if it holds, the evolution of mean outcomes between 2012 and 2014 (pre-intervention period) should be parallel between participating and non-participating schools, and the coefficients on the pre-interventions “placebos” should not be jointly significant.^{A.8}

Selection of non-participating schools. To ensure that non-participating schools are as similar as possible to the participating schools, we use a nearest neighbour matching procedure (with replacement) on the estimated propensity score. We consider all public and private high schools operating in the Paris region that had at least two science track Grade 12 classes in 2015, as this restriction was used in our experimental design to select participating schools (see Section 2 in the main text). We then estimate the probability that the school participated in the experiment in 2015 given a vector of exogenous school characteristics \mathbf{X}_{st} (measured every year between 2012 and 2015) and a vector of the pre-intervention outcomes \mathbf{Y}_{st} (measured in 2012 and 2013) for which spillover effects are measured.^{A.9} We then match each participating school with the non-participating school having the closest propensity score among the schools with the same status (public or private) and located in the same education district (Paris, Créteil or Versailles) as that of the participating school.

^{A.8}Strictly speaking, the parallel trend assumption only requires the coefficient β_{2013} to be non-statistically significant since, as explained above, the comparison between participating and non-participating schools in 2014 could be contaminated by the classroom interventions that were carried on a small scale that year. As shown below, the results show that the parallel trend assumption also holds between 2013 and 2014, suggesting that the contamination effects of these prior interventions are negligible, if any.

^{A.9}The vector of exogenous school characteristics \mathbf{X}_{st} includes the school’s education district (Paris, Créteil or Versailles), whether it is public or private, and the following time-varying characteristics every year between 2012 and 2015: the number of students in Grade 12 (science track), the fraction of female students, and the fraction of high-SES students. The vector of pre-intervention outcomes \mathbf{Y}_{st} in 2012 and 2013 includes the fraction of science track Grade 12 students who enrolled in a STEM program after graduating from high school, the fraction who enrolled in a selective STEM program, and the fraction who enrolled in a male-dominated STEM program (computed separately by year and gender). We do not control for pre-intervention outcomes in 2014 to avoid any contamination by classroom interventions that could have been carried out that year.

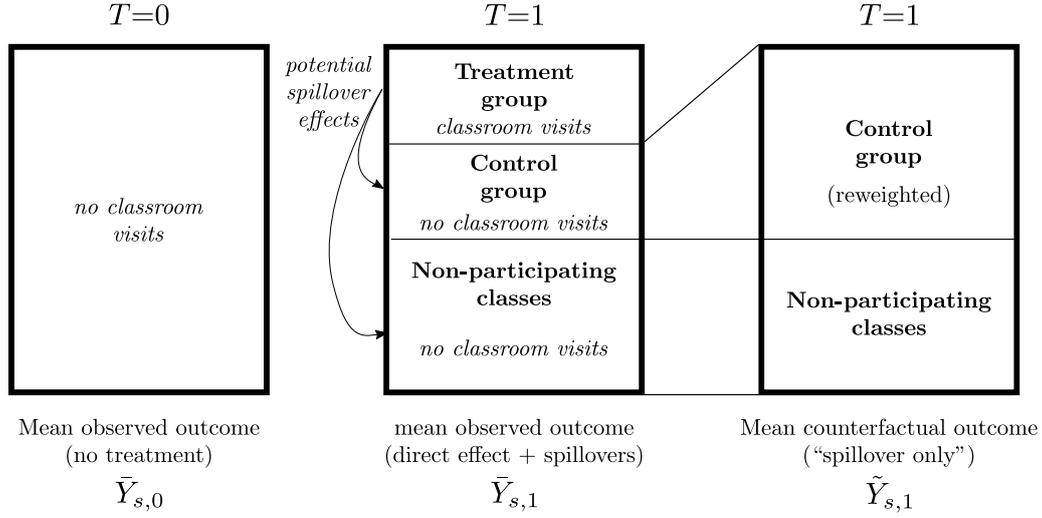
Results. We use Equation (A.11) to estimate the spillover effects of classroom visits on the college enrolment outcomes of Grade 12 students in non-treated classes. The model is estimated separately by gender, and we consider the three main outcomes for which we document significant direct effects of the interventions: enrolment in a STEM undergraduate program, enrolment in a selective STEM program, and enrolment in a male-dominated STEM program. The observations are school-by-year averages weighted by school size. Standard errors are clustered at the school level to account for serial correlation across years.

The results are reported in Table J2. Panel A shows that the non-participating schools selected by the nearest-neighbour matching procedure are reasonably similar to the participating schools in terms of the average college enrolment outcomes of female and male students in the pre-intervention period 2012-2013.

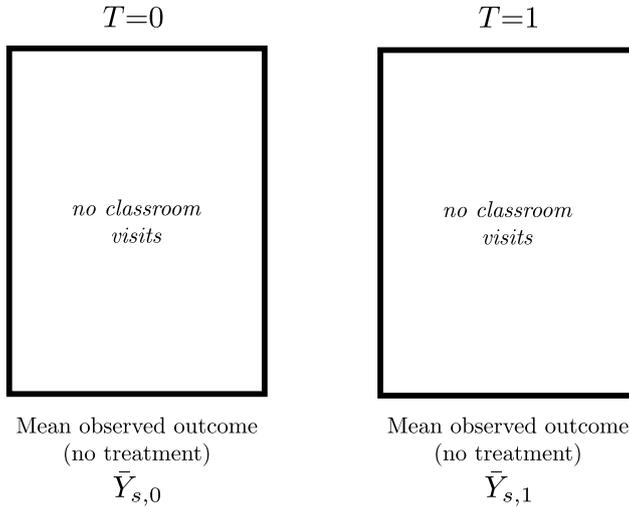
The estimates from the DiD regression are reported in Panel B. In all specifications, the coefficients on (participating school $\times t=2013$) and on (participating school $\times t=2014$) are close to zero and are neither individually nor jointly significant, which lends support to the assumption of common trends between participating and non-participating schools. Overall, the results provide no evidence of significant spillover effects from the classroom visits in participating schools: for all considered outcomes, the coefficient $\hat{\beta}_{2015}$ on (participating school $\times t = 2015$) is close to zero and not statistically significant for both female and male students.

It should, however, be noted that although our estimates are relatively precise, we cannot rule out small to moderate spillover effects. In the presence of positive spillovers, the treatment effects reported in the main text would under-estimate the true direct effect of classroom visits, since the “contamination” of the control group would push the difference between treatment and control classes towards zero. Denoting by Φ the average direct effect of the classroom interventions and by $\Delta (> 0)$ their average indirect effect (through spillovers), the treatment-control difference in mean outcomes, denoted by $\hat{\beta}$, estimates $\Phi - \Delta$ instead of Φ . If we estimate the spillover effects to be at most $\hat{\Delta}^{UB}$, this implies that the size of spillover effects is at most $\hat{\Delta}^{UB}/(\hat{\beta} + \hat{\Delta}^{UB})$ of the size of the direct effect. When we consider the effects on the probability that female students enrol in a selective STEM program, the comparison of treatment and control classes yields an estimated direct effect of $\hat{\beta} = 0.031$ (see Table 6 in the main text, column 2). Based on the results in column 2 of Table J2, the upper bound of the 95% confidence interval for the spillover effects is estimated to be $\hat{\Delta}^{UB} = 0.017$. Hence, in the case of selective STEM enrolment, we cannot reject spillover effects that would be at most 35% of the size of the “true” direct effect $\hat{\beta} + \hat{\Delta}^{UB}$, which in this case would be of 4.8 percentage points. A similar calculation for the spillover effects on male-dominated STEM enrolment yields an upper bound of $\hat{\Delta}^{UB} = 0.025$. Since the estimated direct effect is $\hat{\beta} = 0.034$, we cannot reject spillover effects of at most 42% of the size of the “true” direct effect $\hat{\beta} + \hat{\Delta}^{UB}$, which in that case would be of 5.9 percentage points.

M_1 participating schools ($s \in \mathcal{S}_1$):



M_0 non-participating schools ($s \in \mathcal{S}_0$):



Difference-in-differences estimator of spillover effects:

$$\hat{\Delta} = \frac{1}{M_1} \sum_{s \in \mathcal{S}_1} (\tilde{Y}_{s,1} - \bar{Y}_{s,0}) - \frac{1}{M_0} \sum_{s \in \mathcal{S}_0} (\bar{Y}_{s,1} - \bar{Y}_{s,0})$$

Figure J1 – Spillover Effects of Role Model Interventions: Empirical Strategy

Notes: This figure illustrates the difference-in-differences strategy we implement to estimate the spillover effects of role model interventions for students who were enrolled in participating schools but whose classes were not assigned to the treatment group. These students are either in the classes that were not selected by school principals to participate in the program evaluation or in the participating classes that were randomly assigned to the control group. Our approach consists in comparing the evolution of mean student outcomes (at the school level) in participating ($s \in \mathcal{S}_1$) and non-participating schools ($s \in \mathcal{S}_0$), between the year before the intervention ($T = 0$) and the year of the intervention ($T = 1$). For $T = 1$, we use a weighted average of non-treated classes in each participating school to estimate the counterfactual “spillover-only” outcome that would have been observed if all the students from that school had only been exposed to the spillover effects of classroom interventions, without being directly exposed to a female role model. Average spillover effects are then estimated by comparing this “spillover-only” counterfactual to a “no-treatment” counterfactual. Under the assumption that absent treatment, mean outcomes in participating school would have followed the same evolution as in non-participating schools, the average spillover effects can be estimated by comparing the evolution between $T = 0$ and $T = 1$ of the mean outcome of students in participating schools (using the “spillover-only” counterfactual for period 1) with the corresponding evolution in non-participating schools.

Table J1 – Scope for Spillover Effects: Summary Statistics from the Student Survey

	All	Boys	Girls	Within class	
				Difference (3)–(2) (4)	<i>p</i> -value of diff. (5)
(1)	(2)	(3)	(4)	(5)	
Panel A. Grade 10					
<i>Treatment Group</i>					
Discussed the classroom visit?					
with classmates	0.580	0.498	0.656	0.145	0.000
with other students from the school	0.240	0.200	0.277	0.072	0.000
with other students outside the school	0.203	0.155	0.247	0.098	0.000
Exposed to other science outreach program?					
this school year	0.128	0.138	0.120	–0.011	0.297
in the past	0.182	0.218	0.149	–0.059	0.000
N	6,245	2,989	3,256		
<i>Control Group</i>					
Heard of classroom visits in other classes?					
Yes, definitely	0.018	0.017	0.020	0.001	0.862
Yes, vaguely	0.122	0.117	0.127	0.009	0.244
No	0.859	0.866	0.853	–0.010	0.271
Exposed to programs about science or jobs in science?					
this school year	0.146	0.144	0.148	0.011	0.283
before the end of this school year	0.052	0.059	0.047	–0.014	0.019
in the past	0.322	0.309	0.333	0.025	0.066
N	5,981	2,762	3,219		
Panel B. Grade 12 (science track)					
<i>Treatment Group</i>					
Discussed the classroom visit?					
with classmates	0.629	0.556	0.705	0.131	0.000
with other students from the school	0.269	0.206	0.334	0.114	0.000
with other students outside the school	0.202	0.133	0.275	0.136	0.000
Exposed to other science outreach programs?					
this school year	0.202	0.200	0.204	0.005	0.797
in the past	0.324	0.349	0.299	–0.053	0.025
N	2,642	1,350	1,292		
<i>Control Group</i>					
Heard of classroom visit in other classes?					
Yes, definitely	0.047	0.049	0.045	–0.004	0.645
Yes, vaguely	0.292	0.275	0.308	0.037	0.048
No	0.661	0.676	0.646	–0.033	0.085
Exposed to programs about science or jobs in science?					
this school year	0.287	0.291	0.284	0.011	0.515
before the end of this school year	0.096	0.104	0.088	–0.009	0.403
in the past	0.488	0.461	0.514	0.054	0.028
N	2,594	1,286	1,308		

Notes: The summary statistics in this table are computed from the post-treatment student survey administered in all participating classes between one and six months after the role model interventions. Columns 1, 2, and 3 report average values for all respondents and for boys and girls, respectively, separately by grade level and treatment assignment. The within-class difference in the responses of girls and boys, reported in column 4, is obtained from a regression of the variable of interest on a female dummy, controlling for class fixed effects and clustering standard errors at the school level. The associated *p*-value is reported in column 5.

Table J2 – Difference-in-Differences Estimates of the Spillover Effects of Role Model Interventions on College Enrolment Outcomes, Grade 12 Students, Years 2012–2015

	Grade 12 (science track) students					
	Girls			Boys		
	Unerg. STEM (1)	Selective STEM (2)	Male-dom. STEM (3)	Unerg. STEM (4)	Selective STEM (5)	Male-dom. STEM (6)
Panel A. Baseline means (2012–2013)						
<i>Participating schools</i>						
Mean	0.274	0.145	0.163	0.489	0.265	0.409
Number of schools	88	88	88	87	87	87
Average number of Grade 12 students	107	107	107	108	108	108
<i>Non-participating schools</i>						
Mean	0.265	0.141	0.157	0.473	0.257	0.395
Number of schools	62	62	62	61	61	61
Average number of Grade 12 students	99	99	99	99	99	99
Panel B. Regression estimates						
<i>Pre-trends: participating vs. non-particip. schools (relative to 2012)</i>						
$\hat{\beta}_{2013}$: Particip. school \times ($t=2013$)	0.006 (0.017)	-0.001 (0.014)	0.013 (0.014)	0.003 (0.022)	-0.023 (0.017)	-0.015 (0.021)
$\hat{\beta}_{2014}$: Particip. school \times ($t=2014$)	0.015 (0.019)	0.001 (0.014)	0.014 (0.014)	0.002 (0.018)	-0.020 (0.015)	-0.017 (0.017)
<i>Spillover effects: non-treated students</i>						
$\hat{\beta}_{2015}$: Particip. school \times ($t=2015$)	-0.011 (0.021)	-0.014 (0.016)	-0.009 (0.017)	0.008 (0.023)	-0.011 (0.019)	-0.018 (0.024)
Year fixed effects (omitted: 2012)	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations (school \times year)	601	601	601	593	593	593
<i>Test: common trends ($\hat{\beta}_{2013}=\hat{\beta}_{2014}=0$)</i>						
F-stat	0.33	0.01	0.67	0.01	1.22	0.51
p-value	0.72	0.99	0.52	0.99	0.30	0.60

Notes: This table reports the estimated spillover effects of the role model interventions for students in the non-treated classes of the schools that participated in the program evaluation in 2015, separately for male and female students in Grade 12 (science track). The outcomes we consider are those for which we document significant direct effects of the interventions, i.e. enrolment in a STEM undergraduate program, enrolment in a selective STEM program, and enrolment in a male-dominated STEM program. The results are based on a difference-in-differences specification that compares the outcomes of students in participating and non-participating schools over the period 2012 to 2015, in which the first three years correspond to the pre-intervention period. Non-participating schools are selected among high schools in the Paris region using a nearest neighbour matching procedure (with replacement) on the estimated propensity score. The baseline mean outcomes in participating and non-participating over the pre-intervention period 2012-2013 are reported in Panel A. The regression estimates are reported in Panel B. In all specifications, the dependent variable is the school-by-year average outcome of non-treated students. For non-participating schools throughout the period and for participating schools in the pre-intervention period, this mean outcome is simply the average outcome of all students enrolled in Grade 12 (science track) in the considered year. For participating schools in 2015 (the year of the intervention), this variable is computed as the weighted average outcome of students in the non-participating classes and in the participating classes that were randomly assigned to the control group, with respective weights equal to the share of participating and of non-participating classes (i.e. treatment and control) in the school. The dependent variable is regressed on school fixed effects, year fixed effects (using 2012 as the reference year) and three dummy variables that take the value one if the observation corresponds to a participating school observed in 2013, 2014, and 2015, respectively. The coefficients on the first two dummy variables capture the differential pre-trends between participating and non-participating schools, whereas the coefficient on the third dummy variable measures the spillover effects of role model interventions. All regressions are weighted by school size. Standard errors (in parentheses) are clustered at the school level. The number of schools being used in the regressions for female and male students differs because one of the participating schools and one of the non-participating schools are female-only. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

K Heterogeneous Treatment Effects: Subgroup Analysis

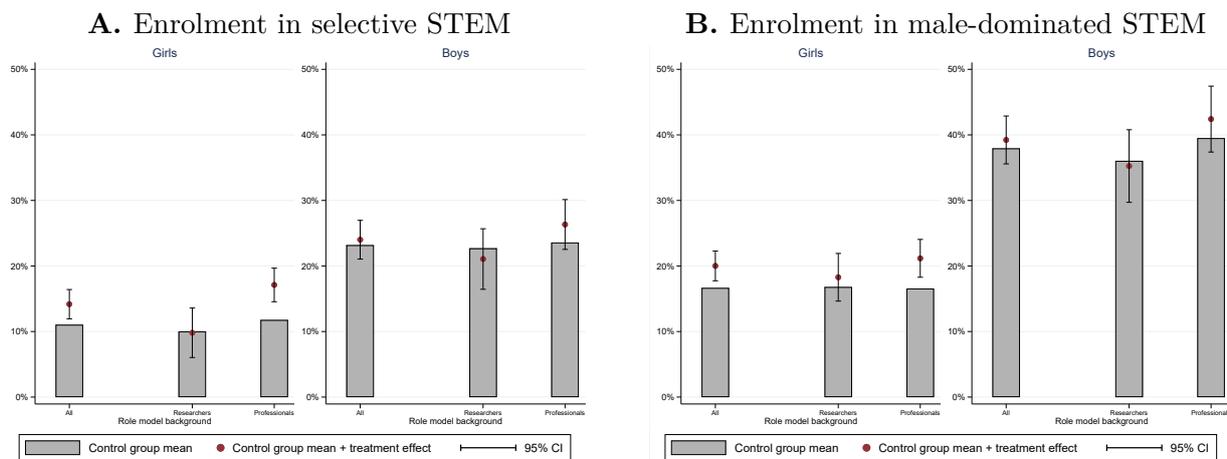


Figure K1 – Grade 12 Students: Enrolment in Selective and Male-Dominated STEM Undergraduate Programs, by Gender and Role Model Background

Notes: The figure shows the fraction of Grade 12 (science track) students enrolled in selective (Panel A) and in male-dominated (Panel B) STEM undergraduate programs after graduating from high school, separately for girls and boys. The filled bars indicate the baseline enrolment rates among students in the control group, both overall and separately by type of female role model who visited the classroom (researcher or professional). The solid dots show the estimated treatment effects (added to the control group means), with 95% confidence intervals denoted by vertical capped bars. The local average treatment effects are estimated from a regression of the outcome of interest on interactions between a classroom visit indicator and two indicators for role model type, using treatment assignment (interacted with role model type) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors are adjusted for clustering at the unit of randomization (class).

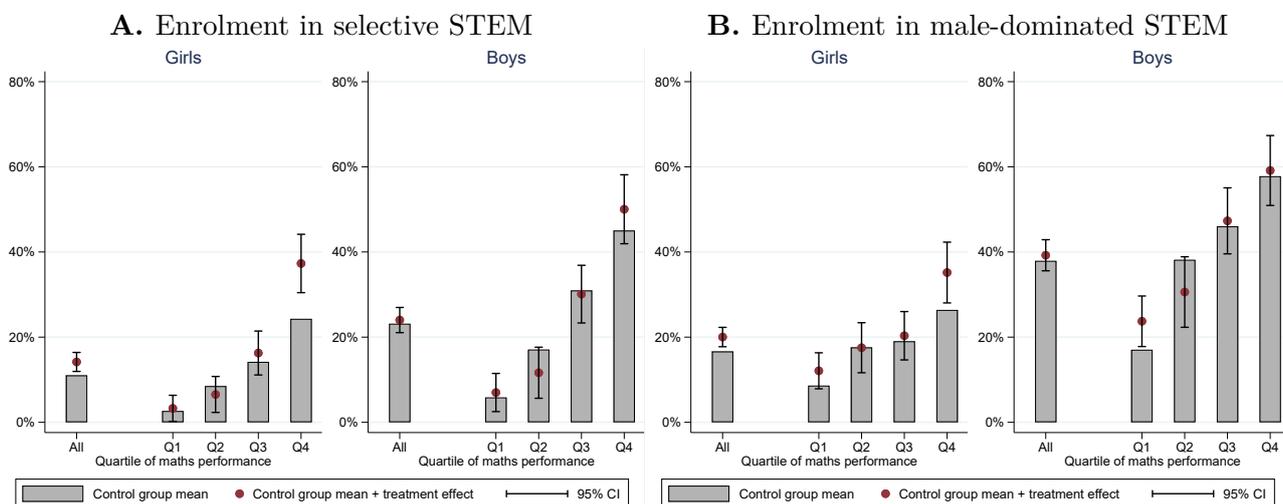


Figure K2 – Grade 12 Students: Enrolment in Selective and Male-Dominated STEM Undergraduate Programs, by Gender and Quartiles of *Baccalauréat* Performance in Maths

Notes: The figure shows the fraction of Grade 12 (science track) students enrolled in selective (Panel A) and in male-dominated (Panel B) STEM undergraduate programs in the year following high school graduation, separately for girls and boys. The filled bars indicate the baseline enrolment rates among students in the control group, both overall and separately by quartile of *Baccalauréat* performance in maths. The solid circles show the estimated treatment effects (added to the control group means), with 95% confidence intervals denoted by vertical capped bars. The local average treatment effects are estimated from a regression of the outcome of interest on interactions between a classroom visit indicator and the quartile of maths performance, using treatment assignment (interacted with the quartiles of maths performance) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors are adjusted for clustering at the unit of randomization (class).

Table K1 – Heterogeneous Treatment Effects on Grade 10 Students’ Outcomes, by Role Model Background

	Girls			Boys		
	Role model background			Role model background		
	Resear- chers	Profes- sionals	<i>p</i> -value of diff. [<i>q</i> -value]	Resear- chers	Profes- sionals	<i>p</i> -value of diff. [<i>q</i> -value]
(1)	(2)	(3)	(4)	(5)	(6)	
Panel A. Enrolment Outcomes						
Grade 11: Science track	0.005 (0.015)	−0.007 (0.015)	0.557 [0.956]	−0.028 (0.018)	0.012 (0.017)	0.102 [0.307]
N	3,180	4,061		2,879	3,580	
Panel B. Student perceptions						
Positive perceptions of science-related careers (index)	0.225*** (0.038)	0.262*** (0.036)	0.474 [0.956]	0.119*** (0.043)	0.197*** (0.033)	0.152 [0.342]
More men in science-related jobs	0.146*** (0.018)	0.160*** (0.017)	0.562 [0.956]	0.166*** (0.020)	0.172*** (0.019)	0.809 [0.810]
Equal gender aptitude for maths (index)	0.056 (0.035)	0.155*** (0.033)	0.035 [0.317]	0.060 (0.048)	0.208*** (0.037)	0.015 [0.080]
Women don’t really like science	0.053*** (0.017)	0.059*** (0.014)	0.774 [0.956]	0.090*** (0.018)	0.111*** (0.018)	0.405 [0.521]
W face discrimination in science-related jobs	0.123*** (0.020)	0.128*** (0.016)	0.851 [0.956]	0.136*** (0.021)	0.167*** (0.017)	0.244 [0.367]
Taste for science subjects (index)	0.009 (0.045)	−0.067 (0.042)	0.213 [0.956]	−0.092** (0.039)	0.036 (0.036)	0.018 [0.080]
Self-concept in maths (index)	0.005 (0.045)	−0.005 (0.037)	0.864 [0.956]	0.010 (0.041)	0.051 (0.039)	0.473 [0.533]
Science-related career aspirations (index)	0.004 (0.043)	0.007 (0.038)	0.956 [0.956]	−0.030 (0.039)	0.032 (0.037)	0.244 [0.367]
N	2,933	3,542		2,608	3,143	

Notes: This table reports estimates of the treatment effects of the role model interventions on the outcomes of Grade 10 students, separately by gender and by background of the female role model who visited the classroom (professional or researcher). Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Columns 1 and 2 (for girls) and columns 4 and 5 (for boys) report the local average treatment effect (LATE) estimates for students whose class was visited by a researcher or a professional, respectively. They are obtained from a regression of the outcome of interest on the interaction between a classroom visit indicator and indicators for the role model being either a researcher or a professional, using treatment assignment (interacted with the role model background indicator) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report both the cluster-robust model-based *p*-value for the difference between the treatment effects estimates for students visited by a professional vs. a researcher and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table K2 – Heterogeneous Treatment Effects on Grade 10 Students’ Outcomes, by Maths Performance

	Girls			Boys		
	Performance in maths			Performance in maths		
	Below median (1)	Above median (2)	<i>p</i> -value of diff. [<i>q</i> -value] (3)	Below median (4)	Above median (5)	<i>p</i> -value of diff. [<i>q</i> -value] (6)
Panel A. Enrolment outcomes						
Grade 11: Science track	-0.007 (0.014)	0.002 (0.017)	0.682 [0.897]	-0.017 (0.019)	0.006 (0.016)	0.364 [0.469]
N	3,584	3,484		3,221	3,075	
Panel B. Student perceptions						
Positive perceptions of science-related careers (index)	0.226*** (0.043)	0.262*** (0.036)	0.535 [0.897]	0.180*** (0.041)	0.146*** (0.039)	0.559 [0.630]
More men in science-related jobs	0.167*** (0.019)	0.142*** (0.017)	0.310 [0.699]	0.188*** (0.020)	0.152*** (0.017)	0.144 [0.325]
Equal gender aptitude for maths (index)	0.060 (0.037)	0.159*** (0.033)	0.047 [0.211]	0.105** (0.044)	0.178*** (0.042)	0.242 [0.363]
Women don’t really like science	0.058*** (0.016)	0.054*** (0.014)	0.842 [0.897]	0.107*** (0.019)	0.096*** (0.017)	0.692 [0.692]
W face discrimination in science-related jobs	0.170*** (0.019)	0.084*** (0.017)	0.001 [0.008]	0.177*** (0.020)	0.131*** (0.019)	0.098 [0.325]
Taste for science subjects (index)	-0.036 (0.043)	-0.029 (0.038)	0.896 [0.897]	-0.071* (0.037)	0.029 (0.033)	0.032 [0.287]
Self-concept in maths (index)	-0.007 (0.038)	0.005 (0.037)	0.813 [0.897]	-0.006 (0.039)	0.070* (0.036)	0.122 [0.325]
Science-related career aspirations (index)	-0.032 (0.040)	0.040 (0.039)	0.186 [0.559]	-0.030 (0.041)	0.037 (0.035)	0.216 [0.363]
N	3,142	3,191		2,825	2,794	

Notes: This table reports estimates of the treatment effects of the role model interventions on Grade 10 students’ outcomes, separately by gender and performance in maths. Each row corresponds to a different linear regression performed separately by gender, with the dependent variable listed on the left. Students’ performance in maths is measured from the grades obtained on the final maths exam of the *Diplôme national du Brevet* at the end of middle school. Columns 1 and 2 (for girls) and columns 4 and 5 (for boys) report the local average treatment effect (LATE) estimates for students below and above the median level of maths performance, respectively. They are obtained from a regression of the outcome of interest on the interaction between a classroom visit indicator and indicators for the student being below or above the median level of performance in maths, using treatment assignment (interacted with the maths performance dummies) as an instrument for treatment receipt. The regression includes school fixed effects (to account for the fact that randomization was stratified by school) and the student characteristics listed in Table 1. Standard errors (shown in parentheses) are adjusted for clustering at the unit of randomization (class). Columns 3 and 6 report both the cluster-robust model-based *p*-value for the difference between the treatment effects estimates for students above vs. below the median performance in maths and, in square brackets, the *p*-value (*q*-value) adjusted for multiple hypotheses testing, using the False Discovery Rate (FDR) control method. Specifically, we use the sharpened two-stage *q*-values introduced in Benjamini et al. (2006) and described in Anderson (2008). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

L Heterogeneous Treatment Effects: Machine Learning Methods

This appendix provides additional information on the machine learning methods we use to (i) describe the heterogeneity in treatment effects and (ii) estimate the correlation between treatment effects on different outcomes. Section L.1 gives an overview of the generic approach developed by Chernozhukov et al. (2018) to estimate, and make inference about, key features of heterogeneous effects in randomized experiments. Section L.2 provides further details on how we implement this method in the context of our study. Section L.3 explains how we extend this method to estimate the correlation between treatment effects. Finally, Section L.4 provides a detailed discussion of the results.

L.1 Description of the Method of Chernozhukov et al. (2018)

Motivation. Reporting treatment effects for various subgroups of participants opens the possibility of overfitting due to the large number of potential sample splits. To address this issue, one option is to specify a certain number of groups *ex ante* in a pre-analysis plan and to tie one’s hands to analyse treatment effect heterogeneity only across these groups, while correcting standard errors for multiple testing.

This approach, however, has the drawback of restricting the analysis to a small number of groups and bears the risk of missing important sources of heterogeneity. Machine Learning (ML) methods provide an attractive alternative to explore treatment effect heterogeneity in a more comprehensive manner (see Athey and Imbens, 2017, for a review). We adopt the approach developed by Chernozhukov et al. (2018) as it appears well suited for our objective. First, this approach makes it possible to conduct valid statistical inference on several objects of interest, such as average treatment effects by heterogeneity groups or the characteristics of individuals with large and small predicted treatment effects. Second, it can be implemented using any ML algorithm, allowing us to test algorithms of different degrees of sophistication, ranging from simple linear models to neural networks. Third, as described in Section L.3, this approach can be extended to estimate the correlation between treatment effects on different outcomes.

Concepts and estimation procedure. Consider an outcome variable denoted by Y . Let $Y(1)$ and $Y(0)$ denote the potential outcomes of a student when her class is and is not visited by a role model, respectively. Let Z be a vector of covariates that characterize the student and the role model who visited the class. The conditional average treatment effect (CATE), denoted by $s_0(Z)$, is defined as follows:

$$s_0(Z) \equiv \mathbb{E}[Y(1) - Y(0)|Z].$$

The approach developed by Chernozhukov et al. (2018) uses the following procedure:

1. Randomly split the data into a *training sample* and an *estimation sample* of equal size (using stratified splitting to balance the proportions of treated and control units in each subsample).
2. Use the training sample to predict the CATE using various ML algorithms. Obtain a ML predictor proxy predictor $S(Z)$.
3. Estimate and perform inference on *features* of the CATE on the estimation sample (see the definition of the features below).
4. Repeat steps 1 to 3 n times and keep track of the estimates obtained for each feature as well as their associated p -values and 95% confidence intervals.

5. For each feature, compute the final estimate as the median of the n available estimates. Compute the p -value for this final estimate as the median of the n available p -values multiplied by two. Compute a 90% confidence interval for the final estimate as the median of the n 95% confidence intervals.

Three features of the CATE. The CATE $s_0(Z)$ is a function for which it is difficult to obtain uniformly valid inference without making strong assumptions. It is, however, possible to obtain inference results on specific *features* of the CATE, such as the expectation of $s_0(Z)$ for heterogeneity groups induced by the ML proxy predictor $S(Z)$.

The Best Linear Predictor (BLP). The first feature of the CATE $s_0(Z)$ is its Best Linear Predictor (BLP) based on the ML proxy predictor $S(Z)$. It is formally defined as follows:

$$\text{BLP}[s_0(Z)|S(Z)] \equiv \arg \min_{f(Z) \in \text{Span}(1, S(Z))} \mathbb{E}[s_0(Z) - f(Z)]^2.$$

Chernozhukov et al. (2018) show that one can identify the BLP of $s_0(Z)$ given $S(Z)$, as well as the projection parameters $\beta_1 = \mathbb{E}[s_0(Z)]$ and $\beta_2 = \text{Cov}(s_0(Z), S(Z))/\text{Var}(S(Z))$, using the following weighted linear projection:

$$Y = \alpha_0 + \alpha B(Z) + \beta_1(T - p(Z)) + \beta_2(T - p(Z))(S(Z) - \mathbb{E}[S(Z)]) + \epsilon, \quad \mathbb{E}[w(Z)\epsilon X] = 0, \quad (\text{A.12})$$

where T is the treatment group indicator; $B(Z)$ is a ML predictor of $Y(0)$ obtained from the training sample; $p(Z)$ is the propensity score (i.e. the conditional probability of being assigned to the treatment group); $w(Z) \equiv \{p(Z)(1 - p(Z))\}^{-1}$ is the weight; and X is the vector of all regressors ($X \equiv [1, B(Z), T - p(Z), (T - p(Z))(S(Z) - \mathbb{E}[S(Z)])]$).

Equation (A.12) can be estimated using weighted least squares, after replacing $\mathbb{E}[S(Z)]$ by its empirical expectation with respect to the estimation sample.

The coefficient β_2 is informative about the correlation between the true CATE, $s_0(Z)$, and the predicted CATE, $S(Z)$. It is equal to one if the prediction is perfect and to zero if $S(Z)$ has no predictive power or if there is no treatment effect heterogeneity, that is if $s_0(Z) = s$. The main purpose of estimating β_2 is to check if the trained ML algorithms are able to detect heterogeneity.^{A.10}

Sorted Group Average Treatment Effects (GATEs). The ML predictor of the CATE, $S(Z)$, can be used to identify groups of individuals with small and large predicted treatment effects. In our setting, this is achieved by sorting students in the estimation sample (indexed by i) according to $S(Z_i)$, the predicted value of their treatment effect given their observable characteristics. We consider the top and bottom quintiles of $S(Z_i)$ and provide ITT estimates for both groups of students.

Classification Analysis (CLAN). The third feature consists in comparing the distribution of observable characteristics of students with the smallest and largest predicted treatment effects.

The three above features—the BLP, the GATEs, and the CLAN—all rely on the existence of a ML predictor $S(Z)$. The BLP provides a means to check if $S(Z)$ detects significant heterogeneity in treatment effects. If it fails to do so, the GATEs and CLAN are not particularly relevant for the analysis, as these features would provide a description of students for whom the predicted treatment effect only differs from the unobserved CATE because of a poor-quality

^{A.10}The intuition behind the formula for β_2 can be grasped by noting that Equation (A.12) is a variant of the simpler equation $Y = \alpha_0 + \alpha B(Z) + \beta'_2 T \cdot S(Z) + \epsilon$. This simpler model implies that $s_0(Z) = \beta'_2 S(Z)$, suggesting that β'_2 provides an estimate for how close the machine learning predictor $S(Z)$ is to the CATE $s_0(Z)$.

prediction.

L.2 Implementation of the Method

This section provides details on the implementation of the method of Chernozhukov et al. (2018) in our empirical setting.

Population of interest. In the main text, we focus on the sample of girls in Grade 12 (science track), since this group of students is the only one for which we find significant treatment effects on enrolment outcomes. We identify which of these female students were most affected by the program and investigate the messages to which they were particularly responsive. Results for boys in Grade 12 can be found in Table L2.

Sample splits and iterations. We perform $n = 100$ iterations of the procedure described in the previous section, which consists in (i) splitting the sample into a training and an estimation subsample of equal size; (ii) predicting the CATE on the training sample using ML methods; and (iii) estimating the three features of the CATE (BLP, GATEs, and CLAN) in the estimation sample.^{A.11} The sample splits are stratified by class, which is the randomization unit in our experimental setting: half of the girls in each Grade 12 class are randomly assigned to the training sample, while the other half are assigned to the estimation sample.

Propensity score. For each student, we estimate the probability that his or her class was randomly assigned to the treatment group. This propensity score $p(Z)$ is equal to one half in most cases, since the treatment was generally assigned to two Grade 10 classes out of four and to one Grade 12 class out of two among the classes that were selected by the school principals. In other cases, the propensity score is not exactly one half.

Machine learning methods. We consider five alternative machine learning methods to estimate the proxy predictor $S(Z)$: Elastic Net, Random Forest, Boosted Trees, Neural Network with feature extraction, and a simple linear model estimated via OLS. These methods are implemented in R using the `caret` package written by Kuhn (2008), while the general approach of Chernozhukov et al. (2018) is implemented by adapting the codes made available online by the authors (Demirer, 2018).

For each machine learning method, the predictor $S(Z)$ is constructed in several steps. First, the model is fitted separately on the treatment and control group students in the training sample. The two fitted models are then applied to the estimation sample to obtain the predicted outcomes $\hat{Y}_i(0)$ and $\hat{Y}_i(1)$ for each individual. Finally, $S(Z)$ is obtained by taking the difference between the two predictions.^{A.12}

For each outcome, we estimate the BLP of the CATE based on the ML method whose associated predictor $S(Z)$ has the highest correlation with the CATE $s_0(Z)$ in the estimation sample. In practice, the best ML method for the BLP targeting of the CATE is chosen in the

^{A.11}The medians of the estimated features of the CATE change little when we repeat the entire procedure using a different seed number to randomly split the data into the training and estimation samples, suggesting that 100 iterations are sufficient for the purpose of empirical convergence.

^{A.12}Predicting outcomes for treatment and control individuals separately before taking the difference, as we do here, may not be the most efficient approach to predict the CATE at finite distance. In our setting, however, alternative ML methods directly designed to detect heterogeneity in treatment effects, such as the causal forests proposed by Wager and Athey (2018), did not improve performance. We therefore decided not to rely on these ML methods for the main analysis.

estimation sample by maximizing the following performance measure:

$$\Lambda \equiv |\beta_2|^2 \text{Var}(S(Z)) = \text{Corr}^2(s_0(Z), S(Z)) \text{Var}(s_0(Z)).$$

The above equation shows that maximizing Λ is equivalent to maximizing the correlation between the ML predictor $S(Z)$ and the CATE $s_0(Z)$.

The best method for the GATEs targeting of the CATE, and hence also for the CLAN, is selected based on the following performance measure:

$$\bar{\Lambda} \equiv \mathbb{E} \left(\sum_{k=1}^K \gamma_k \mathbf{1}(S \in I_k) \right)^2,$$

where K is the number of (equal-sized) heterogeneity groups, $I_k = [l_{k-1}, l_k)$ are non-overlapping intervals that divide the support of S into regions $[l_{k-1}, l_k)$ with equal or unequal masses, and γ_k is the GATE for heterogeneity group k . In practice, both performance measures lead to a similar ranking of ML methods and the methods eventually selected to produce the BLP, the GATEs/CLAN are almost always the same.

Predictors. The covariates we use to train the ML methods are three indicators for the education districts of Paris, Créteil, and Versailles, four indicators for students' socio-economic background (high SES, medium-high SES, medium-low SES, and low SES), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects.^{A.13} Our motivation for including only a few pre-determined covariates in addition to the role model indicators is that we are mostly interested in the treatment effect heterogeneity that arises from the 56 role models (which can be seen as different treatment arms).

L.3 Correlation Between Treatment Effects on Different Outcomes

In this section, we explain how the method of Chernozhukov et al. (2018) can be extended to estimate the correlation between the treatment effects on different outcomes. We show that a set of four linear projections of the CATEs for two outcomes Y^A and Y^B on the ML predictors of the CATEs for these outcomes can be combined to estimate the correlation between the two CATEs under a natural assumption about prediction errors. This approach offers a promising alternative to other methods, such as causal mediation analysis, that are commonly used in the medical and social sciences literature to identify what factors may be part of the causal pathway between an intervention and an outcome. Indeed, our proposed method does not rely on strong identifying assumptions and can be used in any experimental setting, as long as there is a sufficiently large number of observed exogenous covariates.

A new feature: projecting a CATE on the predictor of another CATE. Let Y^A and Y^B denote two distinct outcomes and let $s_0^A(Z)$ and $s_0^B(Z)$ denote the true CATEs of a treatment T on these outcomes, given a vector of exogenous covariates Z characterizing the observational units (indexed by i). Let $\rho_{A,B|Z} \equiv \text{Corr}(s_0^A(Z), s_0^B(Z))$ denote the bivariate correlation between the CATEs on Y^A and Y^B and consider the following weighted linear

^{A.13}Each student in the control group is assigned to the role model who visited his or her high school to ensure that the role model indicators are defined for students in both the treatment and control groups. Moreover, to account for the fact that some Grade 12 students have missing *Baccalauréat* grades (less than 2%), we include indicators for missing grades as controls.

projection:

$$Y^A = \alpha_0 + \alpha B^B(Z) + \beta_1(T - p(Z)) + \beta_2(T - p(Z))(S^B(Z) - \mathbb{E}[S^B(Z)]) + \epsilon, \quad \mathbb{E}[w(Z)\epsilon X] = 0, \quad (\text{A.13})$$

where $B^B(Z)$ and $S^B(Z)$ are a ML predictor of outcome Y^B for individuals in the control group and a ML predictor of the CATE on Y^B , respectively. Both ML predictors are trained using a separate independent sample and are taken as given functions in Equation (A.13). The functions $p(Z)$ and $w(Z)$ and the vector X have the same meaning as in Equation (A.12). Equation (A.13) is estimated using weighted least squares, after replacing $\mathbb{E}[S^B(Z)]$ by its empirical expectation with respect to the estimation sample.

Adapting the BLP equation of Chernozhukov et al. (2018) (Equation 2.1 p. 8) by replacing the ML predictor of the CATE on outcome Y^A by the ML predictor of the CATE for outcome Y^B , we directly obtain that Equation (A.13) identifies

$$\beta_2^{A|B} = \text{Cov}(s_0^A(Z), S^B(Z)) / \text{Var}(S^B(Z)).$$

The sign of $\beta_2^{A|B}$ is informative of the extent to which the CATE on Y^A is positively or negatively correlated with the CATE on Y^B . To show this formally, we denote by η_B the approximation error in $S^B(Z)$ and we write $S^B(Z) = s_0^B(Z) + \eta_B$. Assuming that η_B is independent of $s_0^A(Z)$, we get that $\beta_2^{A|B} = \text{Cov}(s_0^A(Z), s_0^B(Z)) / \text{Var}(S^B(Z))$, which implies that $\beta_2^{A|B}$ and $\rho_{A,B|Z}$ have the same sign.

Combining BLPs to recover the correlation between treatment effects. For any pair of indices $(k, l) \in \{(A, A), (B, B), (A, B), (B, A)\}$, we can identify

$$\beta_2^{k|l} = \text{Cov}(s_0^k(Z), S^l(Z)) / \text{Var}(S^l(Z))$$

from the BLP of $s_0^k(Z)$ on $S^l(Z)$. Writing $S^A(Z) = s_0^A(Z) + \eta_A$, $S^B(Z) = s_0^B(Z) + \eta_B$, and assuming that the prediction errors η_A and η_B are independent of both the predicted functions $s_0^A(Z)$ and $s_0^B(Z)$ in the estimation sample,^{A.14} we can write

$$\beta_2^{k|l} = \text{Cov}(s_0^k(Z), s_0^l(Z)) / (\text{Var}(s_0^l(Z)) + \text{Var}(\eta^l(Z))).$$

Combining the formulas for the four different possible BLPs, we obtain the following expression:

$$\rho_{A,B|Z}^2 = \frac{\beta_2^{A|B} \beta_2^{B|A}}{\beta_2^{B|B} \beta_2^{A|A}},$$

which implies that the correlation $\rho_{A,B|Z}$ is identified as

$$\rho_{A,B|Z} = \text{Sign}(\beta_2^{A|B}) \frac{\sqrt{\beta_2^{A|B} \beta_2^{B|A}}}{\sqrt{\beta_2^{B|B} \beta_2^{A|A}}}. \quad (\text{A.14})$$

Practical implementation. We use the method of Chernozhukov et al. (2018) to estimate the four heterogeneity loading parameters $\beta_2^{A|A}$, $\beta_2^{B|B}$, $\beta_2^{A|B}$, and $\beta_2^{B|A}$. At each iteration of

^{A.14}While it is not possible to prove that the out-of-sample prediction error of a ML predictor is independent from the predicted outcome for any predictor, this assumption seems reasonable when using efficient ML algorithms such as those considered in this paper. As suggestive evidence, we have checked in Monte Carlo simulations that this assumption holds for a large set of simulated functions of Z , which are generated manually and predicted on subsamples of our data. We further checked that the correlation $\rho_{A,B|Z}$ is successfully recovered for various data-generating processes using the formula in Equation (A.14).

the data-splitting process, the bivariate correlation $\rho_{A,B|Z}$ is estimated by plugging the four parameter estimates into Equation (A.14). In theory, $\beta_2^{A|A}$ and $\beta_2^{B|B}$ should both be positive, while $\beta_2^{A|B}$ and $\beta_2^{B|A}$ should have the sign of $\rho_{A,B|Z}$ in each iteration of the data-splitting process. However, it can happen that the estimates $\hat{\beta}_2^{A|A}$, $\hat{\beta}_2^{B|B}$, $\hat{\beta}_2^{A|B}$, and $\hat{\beta}_2^{B|A}$ do not satisfy these conditions due to estimation error, in particular when the predictors $S^A(Z)$ and $S^B(Z)$ are very noisy. In such cases, we do not estimate $\rho_{A,B|Z}$ and discard the corresponding iteration of the data-splitting procedure. We iterate until we reach a number of 100 iterations for which $\hat{\rho}_{A,B|Z}$ can be computed, so that our final estimates are medians computed over an identical number of iterations.^{A.15}

The estimates based on Equation (A.14) can become very large (well above one in absolute value) when the estimates of $\hat{\beta}_2^{A|A}$ or $\hat{\beta}_2^{B|B}$ are close to 0, which can occur when either or both of the predictors $S^A(Z)$ and $S^B(Z)$ are noisy. Reassuringly, we show in Table L7 that the correlation estimates $\hat{\rho}_{A,B|Z}$ are hardly affected when we exclude data splits that yield a poor ML prediction of the CATEs on outcomes Y^A or Y^B , by using only the first 100 iterations of the data-splitting process for which the estimates of the heterogeneity loading parameters $\hat{\beta}_2^{A|A}$ and $\hat{\beta}_2^{B|B}$ are above a minimum threshold t .

In the absence of a closed-form formula for the standard error of $\hat{\rho}_{A,B|Z}$, we estimate its 95% confidence interval as follows.^{A.16} At each iteration m of the data-splitting process, we compute $\hat{\rho}_{A,B|Z}^{(m)}$ (indexed by m) in the estimation sample. When $\hat{\rho}_{A,B|Z}^{(m)}$ can be computed, we estimate its 97.5% confidence interval using a clustered bootstrap procedure, which accounts for the clustered nature of the treatment assignment (at the class level). This procedure consists in creating B replications of the estimation sample m by drawing with replacement $N_c^{(m)}$ female students from each Grade 12 class c , where $N_c^{(m)}$ is the number of female students from class c in the estimation sample m , and computing $\rho_{A,B|Z}$ for this bootstrap sample. For each estimation sample m , this operation is repeated 6,000 times to estimate the 97.5% confidence interval of $\hat{\rho}_{A,B|Z}^{(m)}$ using the bootstrap percentile confidence interval method (Davison and Hinkley, 1997, chap. 5).^{A.17} The 95% confidence interval for $\hat{\rho}_{A,B|Z}$ is then computed as the median of the 97.5% confidence intervals over the first 100 iterations for which $\hat{\rho}_{A,B|Z}^{(m)}$ could be computed—the price of the splitting uncertainty being reflected in the discounting of the confidence level from $1 - \alpha$ to $1 - 2\alpha$.

L.4 Detailed Discussion of the Results

Heterogeneous treatment effects on enrolment outcomes. We use the procedure of Chernozhukov et al. (2018) described in Section L.1 to estimate the different features of the CATE on enrolment in selective or male-dominated STEM programs for girls in Grade 12.

The machine learning results for girls in Grade 12 are reported in Table L1. In Panel A, the estimated ATEs of the interventions on Grade 12 girls' enrolment in selective or male-dominated STEM are very close to those reported in Table 6 in the main text by virtue of the randomization of the sample splits. Turning to heterogeneity, the coefficients on the HET parameter indicate that the ML predictors are strongly and significantly correlated with the CATE on enrolment in selective STEM but not in male-dominated STEM.

Estimates of the sorted group average treatment effects (GATEs) for the top and bottom quintiles of the predicted treatment effects $S(Z)$ are reported in Panel B. They confirm the

^{A.15}For each pair of outcomes (Y^A, Y^B) , Table L6 indicates the proportion of random data splits for which the correlation between CATEs could be computed.

^{A.16}We report confidence intervals rather than p -values because the former are highly skewed, implying that the p -values obtained from bootstrap under normality assumptions are misleading.

^{A.17}The 97.5% confidence interval of $\hat{\rho}_{A,B|Z}^{(m)}$ is estimated using only the bootstrap samples for which $\hat{\rho}_{A,B|Z}$ can be computed.

considerable heterogeneity of treatment effects on selective STEM enrolment among Grade 12 girls, GATEs ranging from a small negative effect in the bottom 20% to a large and significant 13.9 percentage point effect in the top 20%. The lesser heterogeneity in the effects on enrolment in male-dominated STEM is also confirmed, with no statistically significant difference between the top and bottom quintiles of treatment effects.

Panel C describes the characteristics of the 20% most and least affected students (CLAN). The main takeaway is that the ML agnostic approach strongly confirms that the treatment effects on selective STEM enrolment are greater for high-achieving girls in maths and for those who were exposed to a professional rather than a researcher role model. Between the 20% most and least affected female students, the average gap in maths performance rank is as much as 63 percentile ranks; the difference in the probability that the class was visited by a professional is 14.8 percentage points. The results are qualitatively similar for enrolment in male-dominated STEM, but the differences between groups are smaller, which is consistent with the previous finding of less heterogeneous treatment effects for this outcome.

The results in Panel C disclose heterogeneous effects along other dimensions. The 20% of girls with the largest treatment effects on selective STEM enrolment perform significantly better in French and are from higher socioeconomic backgrounds, compared with the least affected 20%. They are also less likely to have been exposed to role models who have children or who graduated in a male-dominated STEM field (maths, physics, engineering), and more likely to have been exposed to role models who participated in the FGiS program the year before. However, the fact that these characteristics are correlated both with students' maths performance and with the role model being either a professional or a researcher makes it difficult to determine their specific contribution to treatment effect heterogeneity.

Heterogeneous treatment effects on potential channels. The main results of the ML approach are reported in Table L3. For each potential channel, we compare the characteristics of students in the top and bottom quintiles of predicted treatment effects. We focus on the two main sources of heterogeneity in the effects on enrolment in selective STEM, i.e. student performance in maths and exposure to a role model with a professional background.^{A.18}

The first key finding is that professionals and researchers were equally effective in debunking stereotypes on gender differences in maths aptitude, while they reinforced students' perceptions that "women don't really like science" and that "women face discrimination in science-related jobs" to a comparable extent. These results suggest that the "gender debiasing" component of the classroom interventions, which emphasized men's and women's equal predisposition for science, cannot explain, alone, why the interventions increased girls' enrolment in selective STEM; otherwise, the two groups of role models would be expected to have similar effects for this outcome, which is not what we find.

By contrast, Table L3 reveals that the professionals were better than the researchers at improving female students' perceptions of science-related jobs and stimulating their aspirations for such careers, while emphasizing less the under-representation of women. Regarding perceptions of science-related careers, girls in the top quintile of treatment effects are 19.2 percentage points more likely to have been visited by a professional compared to girls in the bottom quintile, the difference being statistically significant at the 1% level. Professionals are similarly over-represented among the role models who had the greatest effects on girls' taste for science subjects (22.7 percentage-point gap between the top and bottom quintile of treatment effects), and even more so among those who raised science-related career aspirations the most (38.9 percentage-point gap). The opposite holds for heterogeneous treatment effects on the importance of female under-representation in STEM: compared to the 20% of girls least affected for this outcome, the

^{A.18}The heterogeneity loading parameter of the BLP and the GATEs associated with the best ML method are reported separately for each outcome in Table L4.

20% most affected are 11.2 percentage points more likely to have been visited by a researcher.

The analysis of treatment effect heterogeneity by student maths performance tends to confirm that the messages conveyed by professionals were more effective in influencing female students' choice of study. Indeed, the students who were particularly receptive to these messages are also those for whom we find the strongest impact on STEM enrolment, i.e. high maths achievers. Average maths performance is significantly higher among the students whose perceptions of science-related careers and taste for science subjects improved the most. Conversely, we find fewer high achievers among the girls whose awareness of female under-representation in STEM and perception of gender discrimination increased the most.

While these comparisons on the basis of role model background and student maths performance cannot be given a causal interpretation, they are consistent with the notion that gender-neutral messages about careers in science are more effective than gender-related messages to steer girls towards STEM studies.

Correlation between treatment effects. The correlations between treatment effects for girls in Grade 12 are reported in Table L5, where the covariates that we use to predict treatment effect heterogeneity are the same as in Table L1. The results suggest that some channels were more important than others in steering female students towards STEM studies. The treatment effects on girls' enrolment in selective STEM exhibit a strong positive and significant correlation with the improvement in their perceptions of science-related careers ($\hat{\rho} = 0.96$) and with the improvement in their taste for science subjects ($\hat{\rho} = 0.71$).^{A.19}

While not statistically significant at the 5% level, the remaining correlations give some indication on the role of other candidate channels.^{A.20} They confirm in particular that debiasing girls' attitudes towards gender differences in aptitude for maths is not associated with increased enrolment in selective STEM programs ($\hat{\rho} = 0.19$ with a 95% confidence interval of $[-1.24, 2.05]$) and that, if anything, reinforcing the belief that women are discriminated in science careers tends to deter girls from enrolling in selective STEM programs ($\hat{\rho} = -0.34$ $[-2.22, 0.56]$). By contrast, raising girls' aspirations for careers in science is associated with an increased probability that they enrol in such programs ($\hat{\rho} = 0.36$ $[-0.51, 2.01]$).

^{A.19}The positive correlation between the treatment effects on taste for science and on enrolment in selective STEM suggests that students whose preferences were affected by the intervention also changed their choice of study. These effects, however, are highly heterogeneous (see Table L4): while the treatment effects on taste for science are positive for the 20% most affected girls in Grade 12, they are negative for the 20% least affected, resulting in an average treatment effect close to zero (see Table F3).

^{A.20}We report in Table L5 the lower and upper bounds for the lower and upper limits of the actual 95% confidence interval associated with each estimated correlation. Note that the (unknown) true confidence intervals are likely to be smaller than suggested by the bounds reported in this table.

Table L1 – Heterogeneous Treatment Effects on Selective and Male-Dominated STEM Enrolment for Girls in Grade 12: Estimates based on Machine Learning Methods

Panel A. Best Linear Predictor (BLP) of the CATE $s_0(Z)$ given the ML proxy $S(Z)$				
Parameters:	ATE (β_1)	HET (β_2)		Best ML method
Undergraduate major: selective STEM	0.038	0.762		Elastic Net
<i>p</i> -value	[0.027]	[0.031]		
Undergraduate major: male-dominated STEM	0.036	0.088		Linear model
<i>p</i> -value	[0.064]	[0.731]		
Panel B. Sorted Group Average Treatment Effects (GATEs): 20% most and least affected students				
Heterogeneity group:	20% least affected	20% most affected	Difference most–least	Best ML method
Undergraduate major: selective STEM	−0.004	0.139	0.149	Elastic Net
<i>p</i> -value	[1.000]	[0.014]	[0.026]	
Undergraduate major: male-dominated STEM	0.026	0.061	0.038	Elastic Net
<i>p</i> -value	[1.000]	[0.464]	[1.000]	
Panel C. Average characteristics of the 20% most and least affected students (CLAN)				
Heterogeneity group:	20% least affected	20% most affected	Difference most–least	<i>p</i> -value (upper bound)
Enrolment in selective STEM major				
<i>Student characteristics</i>				
Baccalauréat percentile rank in maths	17.62	81.39	62.85	0.000
Baccalauréat percentile rank in French	41.45	73.44	32.74	0.000
High SES	0.344	0.637	0.302	0.000
<i>Role model characteristics</i>				
Professional	0.494	0.638	0.148	0.001
Participated in the program the year before	0.141	0.233	0.093	0.015
Non-French	0.133	0.183	0.051	0.228
Has children	0.503	0.417	−0.095	0.064
Age	33.09	32.97	−0.11	1.000
Holds/prepares for a Ph.D.	0.692	0.606	−0.080	0.111
Field: Maths, Physics, Engineering	0.316	0.226	−0.099	0.021
Field: Earth and Life Sciences	0.618	0.602	−0.004	1.000
Enrolment in male-dominated major				
<i>Student characteristics</i>				
Baccalauréat percentile rank in maths	19.88	79.02	59.45	0.000
Baccalauréat percentile rank in French	41.22	72.10	31.10	0.000
High SES	0.335	0.628	0.296	0.000
<i>Role model characteristics</i>				
Professional	0.530	0.606	0.078	0.170
Participated in the program the year before	0.142	0.240	0.091	0.021
Non-French	0.153	0.164	0.004	1.000
Has children	0.539	0.418	−0.126	0.010
Age	33.15	32.95	−0.17	1.000
Holds/prepares for a Ph.D.	0.705	0.601	−0.103	0.043
Field: Maths, Physics, Engineering	0.298	0.237	−0.065	0.186
Field: Earth and Life Sciences	0.657	0.585	−0.075	0.170

Notes: This table reports heterogeneous treatment effects of the program on the undergraduate enrolment outcomes of girls in Grade 12 (science track), using the methods developed by Chernozhukov et al. (2018). For each outcome, the conditional average treatment effect (CATE) of role model interventions, $s_0(Z)$, is predicted using five alternative ML methods: Elastic Net, Random Forest, Linear Model, Boosting, and Neural Network. The covariates Z that are used to predict the CATE consist of three indicators for the educational districts of Paris, Créteil, and Versailles, four indicators for students’ socioeconomic background (high, medium-high, medium-low, and low), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects. For each outcome, Panel A reports the parameter estimates and *p*-values (in square brackets) of the Best Linear Predictor (BLP) of the CATE using the best ML method. The coefficients β_1 and β_2 correspond to the average treatment effect (ATE) and heterogeneity loading (HET) parameters in the BLP, respectively. Panel B reports the Sorted Group Average Treatment Effects (GATEs), i.e. the average treatment effects among students in the top and bottom quintiles of the heterogeneous effects induced by the ML proxy predictor $S(Z)$, using the best ML method. Panel C performs a Classification Analysis (CLAN) by comparing the average characteristics of the 20% most and least affected students defined in terms of the ML proxy predictor. The parameter estimates and *p*-values are computed as medians over 100 splits, with nominal levels adjusted to account for the splitting uncertainty. This adjustment implies that the reported *p*-values should be interpreted as upper bounds for the actual *p*-values.

Table L2 – Heterogeneous Treatment Effects on Selective and Male-Dominated STEM Enrolment for Boys in Grade 12: Estimates based on Machine Learning Methods

Panel A. Best Linear Predictor (BLP) of the CATE $s_0(Z)$ given the ML proxy $S(Z)$				
Parameters:	ATE (β_1)	HET (β_2)		Best ML method
Undergraduate major: selective STEM	0.005	0.211		Linear Model
<i>p</i> -value	[1.000]	[0.029]		
Undergraduate major: male-dominated STEM	0.015	0.090		Linear Model
<i>p</i> -value	[1.000]	[0.706]		
Panel B. Sorted Group Average Treatment Effects (GATEs): 20% most and least affected students				
Heterogeneity group:	20% least affected	20% most affected	Difference most–least	Best ML method
Undergraduate major: selective STEM	−0.056	0.061	0.116	Linear Model
<i>p</i> -value	[0.358]	[0.283]	[0.086]	
Undergraduate major: male-dominated STEM	0.051	0.010	−0.030	Boosting
<i>p</i> -value	[0.771]	[1.000]	[1.000]	
Panel C. Average characteristics of the 20% most and least affected students (CLAN)				
Heterogeneity group:	20% least affected	20% most affected	Difference most–least	<i>p</i> -value (upper bound)
Enrolment in selective STEM major				
<i>Student characteristics</i>				
Baccalauréat percentile rank in maths	48.64	53.26	4.03	0.194
Baccalauréat percentile rank in French	39.95	50.94	10.45	0.000
High SES	0.495	0.494	−0.004	1.000
<i>Role model characteristics</i>				
Professional	0.395	0.600	0.214	0.000
Participated in the program the year before	0.200	0.275	0.070	0.112
Non-French	0.141	0.188	0.051	0.208
Has children	0.413	0.492	0.080	0.140
Age	32.08	33.73	1.58	0.001
Holds/prepares for a Ph.D.	0.707	0.664	−0.070	0.206
Field: Maths, Physics, Engineering	0.359	0.236	−0.133	0.001
Field: Earth and Life Sciences	0.541	0.688	0.157	0.000
Enrolment in male-dominated major				
<i>Student characteristics</i>				
Baccalauréat percentile rank in maths	54.72	50.21	−4.46	0.123
Baccalauréat percentile rank in French	45.41	47.25	1.38	1.000
High SES	0.465	0.527	0.068	0.248
<i>Role model characteristics</i>				
Professional	0.484	0.531	0.052	0.436
Participated in the program the year before	0.191	0.172	−0.019	1.000
Non-French	0.154	0.124	−0.025	0.820
Has children	0.489	0.489	0.004	1.000
Age	33.32	34.34	0.16	1.000
Holds/prepares for a Ph.D.	0.660	0.682	0.020	1.000
Field: Maths, Physics, Engineering	0.295	0.277	−0.015	1.000
Field: Earth and Life Sciences	0.576	0.654	0.074	0.167

Notes: This table reports heterogeneous treatment effects of the program on the undergraduate enrolment outcomes of boys in Grade 12 (science track), using the methods developed by Chernozhukov et al. (2018). For each outcome, the conditional average treatment effect (CATE) of role model interventions, $s_0(Z)$, is predicted using five alternative ML methods: Elastic Net, Random Forest, Linear Model, Boosting, and Neural Network. The covariates Z that are used to predict the CATE consist of three indicators for the educational districts of Paris, Créteil, and Versailles, four indicators for students’ socioeconomic background (high, medium-high, medium-low, and low), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects. For each outcome, Panel A reports the parameter estimates and *p*-values (in square brackets) of the Best Linear Predictor (BLP) of the CATE using the best ML method. The coefficients β_1 and β_2 correspond to the average treatment effect (ATE) and heterogeneity loading (HET) parameters in the BLP, respectively. Panel B reports the Sorted Group Average Treatment Effects (GATEs), i.e. the average treatment effects among students in the top and bottom quintiles of the heterogeneous effects induced by the ML proxy predictor $S(Z)$, using the best ML method. Panel C performs a Classification Analysis (CLAN) by comparing the average characteristics of the 20% most and least affected students defined in terms of the ML proxy predictor. The parameter estimates and *p*-values are computed as medians over 100 splits, with nominal levels adjusted to account for the splitting uncertainty. This adjustment implies that the reported *p*-values should be interpreted as upper bounds for the actual *p*-values.

Table L3 – Heterogeneous Treatment Effects on Student Perceptions: Average Characteristics of the Most and Least Affected Girls in Grade 12

	20% least affected (1)	20% most affected (2)	Difference most–least (3)	<i>p</i> -value (upper bound) (4)
<i>Positive perceptions of science-related careers (index)</i>				
Mean Baccalauréat percentile rank in maths	26.62	73.29	46.85	0.000
Class visited by professional	0.483	0.675	0.192	0.000
<i>More men in science-related jobs</i>				
Mean Baccalauréat percentile rank in maths	74.87	25.00	−51.03	0.000
Class visited by professional	0.614	0.511	−0.112	0.031
<i>Equal gender aptitude for maths (index)</i>				
Mean Baccalauréat percentile rank in maths	42.77	50.58	7.89	0.003
Class visited by professional	0.622	0.563	−0.058	0.403
<i>Women don't really like science</i>				
Mean Baccalauréat percentile rank in maths	44.47	50.57	5.07	0.090
Class visited by professional	0.592	0.540	−0.035	0.908
<i>Women face discrimination in science-related jobs</i>				
Mean Baccalauréat percentile rank in maths	52.15	42.79	−8.81	0.001
Class visited by professional	0.568	0.570	0.011	1.000
<i>Taste for science subjects (index)</i>				
Mean Baccalauréat percentile rank in maths	41.36	54.71	13.63	0.000
Class visited by professional	0.436	0.678	0.227	0.000
<i>Self-concept in maths (index)</i>				
Mean Baccalauréat percentile rank in maths	52.22	42.10	−10.65	0.000
Class visited by professional	0.512	0.582	0.071	0.240
<i>Science-related career aspirations (index)</i>				
Mean Baccalauréat percentile rank in maths	44.70	47.78	2.36	0.712
Class visited by professional	0.375	0.762	0.389	0.000

Notes: This table reports the average characteristics of Grade 12 girls in the top and bottom quintile of predicted treatment effects on student perceptions, using the methods developed by Chernozhukov et al. (2018). For each outcome, the conditional average treatment effect (CATE) of role model interventions, $s_0(Z)$, is predicted using five alternative ML methods: Elastic Net, Random Forest, Linear Model, Boosting, and Neural Network. The covariates Z that are used to predict the CATE consist of three indicators for the educational districts of Paris, Créteil, and Versailles, four indicators for students' socioeconomic background (high, medium-high, medium-low, and low), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects. For each outcome, the table compares the average characteristics of the students in the top and bottom quintile of treatment effects, as predicted by the best ML proxy predictor based on the Group average treatment effects (GATEs) targeting of the CATE. The characteristics reported in this table are the students' average percentile rank in maths in the *Baccalauréat* exams and the share exposed to a role model with a professional rather a research background. The parameter estimates and *p*-values are computed as medians over 100 splits, with nominal levels adjusted to account for the splitting uncertainty. This adjustment implies that the reported *p*-values should be interpreted as upper bounds for the actual *p*-values. The average treatment effects among the 20% most and least affected students can be found in Panel B of Table L4.

Table L4 – Heterogeneous Treatment Effect on Student Outcomes for Girls in Grade 12: Estimates Based on Machine Learning Methods

Panel A. Best Linear Predictor (BLP) of the CATE $s_0(Z)$ given the ML proxy $S(Z)$				
Parameters:	ATE (β_1)	HET (β_2)		Best ML method
<i>(p-values in square brackets)</i>				
Undergraduate major: selective STEM	0.038 [0.027]	0.762 [0.031]		Elastic Net
Undergraduate major: male-dominated STEM	0.036 [0.064]	0.088 [0.731]		Linear model
Positive perceptions of science-related careers (index)	0.298 [0.000]	0.400 [0.555]		Elastic Net
More men in science-related jobs	0.119 [0.000]	0.657 [0.593]		Elastic Net
Equal gender aptitude for maths (index)	0.117 [0.010]	0.324 [0.108]		Random Forest
Women don't really like science	0.044 [0.002]	0.095 [0.566]		Linear model
Women face discrimination in science-related jobs	0.105 [0.000]	0.496 [0.012]		Random Forest
Taste for science subjects (index)	0.008 [1.000]	0.170 [0.137]		Linear Model
Self-concept in maths (index)	0.029 [0.988]	0.257 [0.010]		Linear Model
Science-related career aspirations (index)	0.077 [0.263]	0.245 [0.013]		Linear Model
Panel B. Average predicted treatment effects among the most/least affected groups (GATEs)				
Heterogeneity group:	20% least affected	20% most affected	Difference most–least	Best ML method
<i>(p-values in square brackets)</i>				
Undergraduate major: selective STEM	−0.004 [1.000]	0.139 [0.014]	0.149 [0.026]	Elastic Net
Undergraduate major: male-dominated STEM	0.026 [1.000]	0.061 [0.464]	0.038 [1.000]	Elastic Net
Positive perceptions of science-related careers (index)	0.316 [0.037]	0.400 [0.001]	0.104 [1.000]	Elastic Net
More men in science-related jobs	0.096 [0.048]	0.160 [0.022]	0.065 [0.766]	Elastic Net
Equal gender aptitude for maths (index)	0.019 [1.000]	0.246 [0.037]	0.210 [0.332]	Random Forest
Women don't really like science	0.026 [0.758]	0.073 [0.078]	0.039 [0.772]	Linear model
Women face discrimination in science-related jobs	−0.007 [1.000]	0.195 [0.003]	0.197 [0.038]	Random Forest
Taste for science subjects (index)	−0.112 [0.594]	0.138 [0.369]	0.251 [0.196]	Linear model
Self-concept in maths (index)	−0.122 [0.416]	0.191 [0.063]	0.317 [0.035]	Linear model
Science-related career aspirations (index)	−0.142 [0.394]	0.268 [0.047]	0.387 [0.041]	Linear model

Notes: This table reports heterogeneous treatment effects of the program on student outcomes for girls in Grade 12 (science track), using the methods developed by Chernozhukov et al. (2018). For each outcome, the conditional average treatment effect (CATE) of role model interventions, $s_0(Z)$, is predicted using five alternative ML methods: Elastic Net, Random Forest, Linear Model, Boosting, and Neural Network. The covariates Z that are used to predict the CATE consist of three indicators for the educational districts of Paris, Créteil, and Versailles, four indicators for students' socioeconomic background (high, medium-high, medium-low, and low), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects. For each outcome, Panel A reports the parameter estimates and p -values (in square brackets) of the Best Linear Predictor (BLP) of the CATE using the best ML method. The coefficients β_1 and β_2 correspond to the average treatment effect (ATE) and heterogeneity loading (HET) parameters in the BLP, respectively. Panel B reports the Sorted Group Average Treatment Effects (GATEs), i.e. the average treatment effects among students in the top and bottom quintiles of the heterogeneous effects induced by the ML proxy predictor $S(Z)$, using the best ML method.

Table L5 – Correlation between Conditional Average Treatment Effects (CATEs) for Girls in Grade 12

	Bivariate correlation with the CATE on enrolment in a selective STEM program	
	Estimate (1)	95% confidence interval (2)
<i>Conditional average treatment effect (CATE) on:</i>		
Positive perception of science-related careers (index)	0.96	[0.21, 5.30]
More men in science-related jobs	-0.68	[-3.23, -0.01]
Equal gender aptitude for maths (index)	0.19	[-1.24, 2.05]
Women don't really like science	0.21	[-1.43, 3.23]
Women face discrimination in science-related jobs	-0.34	[-2.22, 0.56]
Taste for science subjects (index)	0.71	[0.04, 3.96]
Self-concept in maths (index)	-0.07	[-1.84, 1.40]
Science-related career aspirations (index)	0.36	[-0.51, 2.01]

Notes: This table reports, for girls in Grade 12, estimates of the bivariate correlation $\rho_{A,B|Z}$ between the Conditional Average Treatment Effect (CATE) on enrolment in a selective STEM program, denoted by $s_0^B(Z)$, and the CATE on each of the potential channels listed in the table, denoted by $s_0^A(Z)$. The proxy predictor of the CATE on selective STEM enrolment, denoted by $S^B(Z)$, is estimated using the Elastic Net method, as it has the best performance based on the Best Linear Predictor (BLP) targeting of the CATE for this outcome. The proxy predictor of the CATE on the potential mediator Y^A , denoted by $S^A(Z)$, is estimated using the ML method that has the best performance based on the BLP targeting of the CATE on the corresponding outcome. An indication of the quality of these predictions is provided by the heterogeneity loading (HET) parameter of the BLP (see Table L4, Panel A). For each random split of the data, the correlation coefficient $\rho_{A,B|Z}$ is estimated as $\hat{\rho}_{A,B|Z} = \text{Sign}(\hat{\beta}_2^{A|B})(\hat{\beta}_2^{A|B} \hat{\beta}_2^{B|A})^{\frac{1}{2}} / (\hat{\beta}_2^{A|A})^{\frac{1}{2}} (\hat{\beta}_2^{B|B})^{\frac{1}{2}}$, where $\hat{\beta}_2^{k|l}$ is the estimated heterogeneity loading parameter of the BLP of $s_0^k(Z)$ based on $S^l(Z)$ (with $k, l \in \{A, B\}$), using the methods in Chernozhukov et al. (2018). The covariates Z that are used to predict the CATEs consist of three indicators for the educational districts of Paris, Créteil, and Versailles, four indicators for students' socioeconomic background (high, medium-high, medium-low, and low), their age, their overall percentile rank in the *Baccalauréat* exam, their percentile ranks in the French and maths tests of the exam, and a vector of 56 role model fixed effects. For each pair of outcomes, columns 1 and 2 report the estimated correlation between the CATEs and its 95% confidence interval, respectively. Estimates and confidence intervals are computed as medians over the first 100 random data splits for which $\hat{\rho}_{A,B|Z}$ can be computed. For each data split, the confidence intervals are obtained using a clustered bootstrap procedure. The nominal level of the median of confidence intervals is adjusted to account for the splitting uncertainty, using the method of Chernozhukov et al. (2018). This adjustment implies that the reported confidence intervals should be interpreted as lower and upper bounds for the true lower and upper limits of the confidence intervals.

Table L6 – Proportion of Random Data Splits for which the Correlation between Conditional Average Treatment Effects (CATEs) can be Computed, Girls in Grade 12

	Proportion of data splits such that			
	$\hat{\rho}_{A,B Z}$ can be computed*	$\hat{\beta}_2^{B B} > 0$	$\hat{\beta}_2^{A A} > 0$	$\hat{\beta}_2^{A B} \hat{\beta}_2^{B A} \geq 0$
	(1)	(2)	(3)	(4)
<i>When outcome Y^B is enrolment in a selective STEM program and outcome Y^A is:</i>				
Positive perception of science-related careers (index)	0.80	1.00	0.86	0.90
More men in science-related jobs	0.68	0.99	0.89	0.73
Equal gender aptitude for maths (index)	0.35	1.00	0.98	0.36
Women don't really like science	0.34	0.99	0.84	0.40
Women face discrimination in science-related jobs	0.62	1.00	1.00	0.62
Taste for science subjects (index)	0.81	0.99	0.97	0.83
Self-concept in maths (index)	0.39	0.99	1.00	0.40
Science-related career aspirations (index)	0.64	0.99	1.00	0.65
Number of data splits	3,000	3,000	3,000	3,000

Notes: This table reports, for the sample of girls in Grade 12 (science track), the proportion of random data splits (out of 3,000) for which the correlation between the Conditional Average Treatment Effects (CATEs) on outcomes Y^A and Y^B could be computed. Outcome Y^B is always enrolment in selective STEM, while Y^A is the outcome listed in the corresponding row of the table. Conditional on the covariates Z , the CATEs on outcomes Y^A and Y^B are denoted by $s_0^A(Z)$ and $s_0^B(Z)$, respectively, whereas their ML proxy predictors are denoted by $S^A(Z)$ and $S^B(Z)$, respectively. For each random split, the correlation coefficient $\rho_{A,B|Z}$ is estimated as $\hat{\rho}_{A,B|Z} = \text{Sign}(\hat{\beta}_2^{A|B})(\hat{\beta}_2^{A|B} \hat{\beta}_2^{B|A})^{\frac{1}{2}} / (\hat{\beta}_2^{A|A})^{\frac{1}{2}} (\hat{\beta}_2^{B|B})^{\frac{1}{2}}$, where $\hat{\beta}_2^{k|l}$ is the estimated heterogeneity loading parameter of the Best Linear Predictor (BLP) of $s_0^k(Z)$ based on $S^l(Z)$ (with $k, l \in \{A, B\}$), using the methods in Chernozhukov et al. (2018). Column 1 indicates the fraction of data splits for which $\hat{\rho}_{A,B|Z}$ could be computed. The next three columns report the fraction of sample splits for which each of the three conditions to compute $\hat{\rho}_{A,B|Z}$ is met, i.e. $\hat{\beta}_2^{B|B} > 0$ (column 2), $\hat{\beta}_2^{A|A} > 0$ (column 3), and $\hat{\beta}_2^{A|B} \hat{\beta}_2^{B|A} \geq 0$ (column 4). The proportion of random splits such that $\hat{\beta}_2^{B|B} > 0$ varies slightly across rows because for each pair of outcomes (Y^A, Y^B), the sample is restricted to observations with non-missing values for both outcomes. Table L5 reports the median and 95% confidence interval of $\hat{\rho}_{A,B|Z}$ over the first 100 random data splits for which $\hat{\rho}_{A,B|Z}$ can be computed. Details are provided in Section L.3 of the Appendix.

Table L7 – Correlation between Conditional Average Treatment Effects (CATEs) for Girls in Grade 12: Sensitivity Analysis

	Bivariate correlation with the CATE on enrolment in a selective STEM program (from first 100 valid iterations)		
	Estimate ($\hat{\rho}_{A,B Z}$)	95% confidence interval	Proportion of valid iterations
Panel A. Data splits such that $\hat{\beta}_2^{A A} > 0.1$, $\hat{\beta}_2^{B B} > 0.1$ and $\hat{\beta}_2^{A B}\hat{\beta}_2^{B A} \geq 0$			
<i>Conditional average treatment effect (CATE) on:</i>			
Positive perception of science-related careers (index)	0.94	[0.20, 5.10]	0.73
More men in science-related jobs	-0.68	[-3.20, -0.01]	0.65
Equal gender aptitude for maths (index)	0.19	[-1.21, 1.97]	0.33
Women don't really like science	0.18	[-1.40, 2.70]	0.19
Women face discrimination in science-related jobs	-0.34	[-2.22, 0.56]	0.61
Taste for science subjects (index)	0.68	[0.07, 3.42]	0.66
Self-concept in maths (index)	-0.07	[-1.83, 1.40]	0.38
Science-related career aspirations (index)	0.36	[-0.52, 1.99]	0.62
Panel B. Data splits such that $\hat{\beta}_2^{A A} > 0.2$, $\hat{\beta}_2^{B B} > 0.2$ and $\hat{\beta}_2^{A B}\hat{\beta}_2^{B A} \geq 0$			
<i>Conditional average treatment effect (CATE) on:</i>			
Positive perception of science-related careers (index)	0.93	[0.20, 4.89]	0.64
More men in science-related jobs	-0.66	[-3.15, -0.03]	0.62
Equal gender aptitude for maths (index)	0.16	[-1.18, 1.80]	0.28
Women don't really like science	0.18	[-0.87, 2.18]	0.05
Women face discrimination in science-related jobs	-0.31	[-2.17, 0.62]	0.59
Taste for science subjects (index)	0.59	[0.07, 2.48]	0.34
Self-concept in maths (index)	-0.07	[-1.71, 1.37]	0.28
Science-related career aspirations (index)	0.32	[-0.44, 1.78]	0.48

Notes: Similarly to Table L5, this table reports, for girls in Grade 12 (science track), the estimates of the bivariate correlation $\rho_{A,B|Z}$ between the Conditional Average Treatment Effect (CATE) on enrolment in a selective STEM program, denoted by $s_0^B(Z)$, and the CATE on each of the potential channels listed in the table, denoted by $s_0^A(Z)$. The difference is that estimates provided in this table are obtained using only iterations of the data-splitting process for which the estimates of the heterogeneity loading parameters $\hat{\beta}_2^{A|A}$ and $\hat{\beta}_2^{B|B}$ are above a certain threshold. This threshold is set at 0.1 in Panel A and at 0.2 in Panel B. These restrictions are applied to check the sensitivity of the correlation estimates to excluding data splits that yield a poor ML prediction of the CATEs on outcomes Y^A or Y^B . Column 3 indicates the proportion of data splits satisfying the restrictions specified in each panel's heading. The estimates and 95% confidence intervals reported in columns 1 and 2 are obtained using the first 100 data splits satisfying these restrictions. Additional details are provided in the notes of Table L5.

Appendix References

- Anderson, Michael L.**, “Multiple Inference and Gender Differences in the Effects of Early Intervention: A Reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects,” *Journal of the American Statistical Association*, 2008, 103 (484).
- Atelier Parisien d’Urbanisme (APUR)**, DEPARTEMENT: *Délimitation des 8 départements d’Île-de-France [database]*, Atelier Parisien d’Urbanisme, 2018. <https://opendata.apur.org/datasets/Apur::departement>. Accessed 6 June 2020.
- Athey, Susan and Guido W. Imbens**, “The Econometrics of Randomized Experiments,” in Esther Duflo and Abhijit V. Banerjee, eds., *Handbook of Economic Field Experiments*, Vol. 1, Elsevier, 2017, pp. 73–140.
- Beede, David, Tiffany Julian, David Langdon, George McKittrick, Beethika Khan, and Mark Doms**, “Women in STEM: A Gender Gap to Innovation,” 2011. U.S. Department of Commerce, Economics and Statistics Administration, Issue Brief No. 04-11.
- Benjamini, Yoav, Abba M. Krieger, and Daniel Yekutieli**, “Adaptive Linear Step-up Procedures that Control the False Discovery Rate,” *Biometrika*, 2006, 93 (3), 491–507.
- Chernozhukov, Victor, Mert Demirer, Esther Duflo, and Iván Fernández-Val**, “Generic Machine Learning Inference on Heterogenous Treatment Effects in Randomized Experiments,” 2018. NBER Working Paper No. 24678.
- Conférence des Grandes Écoles (CGE)**, *L’insertion des diplômés des Grandes écoles. Résultats de l’enquête 2018*, Conférence des Grandes Écoles, Paris, 2018. <https://www.cge.asso.fr/themencode-pdf-viewer/?file=https://www.cge.asso.fr/wp-content/uploads/2018/06/2018-06-19-Rapport-2018.pdf>. Accessed 28 August 2019.
- Davison, Anthony C. and David V. Hinkley**, *Bootstrap Methods and their Application*, Cambridge University Press, 1997.
- Demirer, Mert**, *MLInference [R code]*, NBER Summer Institute 2018 presentation “Machine learning meet randomistas: useful ML tools for empirical researchers” by E. Duflo, 2018. <https://github.com/demirermert/MLInference/>. Accessed 4 May 2018.
- Direction des Études, de la Prospective et de la Performance (MENJ-DEPP)**, *Organisation des Concours et Examens Nationaux (OCEAN) [database]: OCEAN-DNB 2010–2015, OCEAN-BAC 2015 and 2016*, Ministère de l’Éducation Nationale et de la Jeunesse, 2017. Accessed 11 October 2017.
- Duflo, Esther and Emmanuel Saez**, “The Role of Information and Social Interactions in Retirement Plan Decisions: Evidence from a Randomized Experiment,” *The Quarterly Journal of Economics*, 2003, 118 (3), 815–842.
- Fisher, Ronald A.**, *The Design of Experiments*, McMillan, 1935.
- Gayral-Taminh, Martine, Tomohiro Matsuda, Sylvie Bourdet-Loubère, Valérie Lauwers-Cances, Jean-Philippe Raynaud, and Hélène Grandjean**, “Auto-évaluation de la qualité de vie d’enfants de 6 à 12 ans : construction et premières étapes de validation du KidIQol, outil générique présenté sur ordinateur,” *Santé Publique*, 2005, 17 (2), 167–177.
- Imbens, Guido W. and Donald B. Rubin**, *Causal Inference in Statistics, Social, and Biomedical Sciences*, Cambridge University Press, 2015.
- Kuhn, Max**, “Building Predictive Models in R using the caret Package,” *Journal of Statistical Software*, 2008, 28 (5), 1–26.
- McDonald, Judith A. and Robert J. Thornton**, “Do New Male and Female College Graduates Receive Unequal Pay?,” *Journal of Human Resources*, 2007, 42 (1), 32–48.

- Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation (MESRI)**, *Enquête d'Insertion Professionnelle à 30 Mois des Diplômés de Master 2015 [database]*, Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation, 2018. https://data.enseignementsup-recherche.gouv.fr/explore/dataset/fr-esr-insertion_professionnelle-master_donnees_nationales/information/. Accessed 28 August 2019.
- Paz, Lourenço S. and James E. West**, “Should We Trust Clustered Standard Errors? A Comparison with Randomization-Based Methods,” 2019. NBER Working Paper No. 25926.
- Rectorat de l'Académie de Créteil - Pôle Académique de la Prospective et de la Performance (PAPP)**, *Base Élèves Académique (BEA) [database]: ELH 2012–2014, ELC 2013–2016, ELG 2015*, Rectorat de l'Académie de Créteil, 2017. Accessed 11 January 2017.
- Rectorat de l'Académie de Paris - Service Statistique Académique (SSA)**, *Base Élèves Académique (BEA) [database]: ELH 2012–2014, ELC 2013–2016, ELG 2015*, Rectorat de l'Académie de Paris, 2017. Accessed 9 February 2017.
- Rectorat de l'Académie de Versailles - Délégation Académique à la Prospective et à l'Évaluation des Performances (DAPEP)**, *Base Élèves Académique (BEA) [database]: ELH 2012–2014, ELC 2013–2016, ELG 2015*, Rectorat de l'Académie de Versailles, 2017. Accessed 10 January 2017.
- Rosenbaum, Paul R.**, *Observational Studies*, Springer, 2002.
- , *Design of Observational Studies*, Springer Series in Statistics, 2010.
- Sous-direction des Services d'Information et des Études Statistiques (MESRI-DGESIP/DGRI-SIES)**, *Système d'Information sur le Suivi de l'Étudiant (SISE) [database]: SISE-UNIV 2013–2016, SISE-ENS 2013–2016, SISE-INGE 2013–2016, SISE-MANA 2013–2016, SISE-PRIV 2013–2016*, Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation (MESRI), Direction générale de l'enseignement supérieur et de l'insertion professionnelle (DGESIP), Direction générale de la recherche et de l'innovation (DGRI), 2017. Accessed 15 December 2017.
- Vazquez-Bare, Gonzalo**, “Identification and Estimation of Spillover Effects in Randomized Experiments,” *Journal of Econometrics*, forthcoming.
- Wager, Stefan and Susan Athey**, “Estimation and Inference of Heterogeneous Treatment Effects using Random Forests,” *Journal of the American Statistical Association*, 2018, 113 (523), 1228–1242.