Can Female Role Models Reduce the Gender Gap in Science? Evidence from Classroom Interventions in French High Schools

Thomas Breda
CNRS and PSE

Julien Grenet
CNRS and PSE

Marion Monnet
PSE

Clémentine Van Effenterre
Harvard Kennedy School

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Female Under-representation in STEM

- Female under-representation in STEM fields accounts for a significant part of the gender pay gap among college graduates
  (Brown and Corcoran, 1997; Black et al., 2008; Blau and Kahn, 2008)
- Cannot be explained by gender differences in achievement
  (Hyde, 2005; Spelke, 2005)
- Demand-side: mixed evidence on hiring and evaluation biases
  (Ceci and Williams, 2011; Reuben et al., 2014: Hengel, 2017)
- Supply-side: differences in educational choices
  - gender differences in preferences and psychological traits
    Niederle and Versterlund (2007, 2010); Buser et al. (2014)
  - generally influenced by social norms and gender stereotypes
    Glick et al. (1995); Deaux and LaFrance (1998); Tiedemann (2000)

Female Role Models as a Remedy?

- **What female role models can do:**
  - foster identification to increase sense of fit in science
  - overcome stereotype threat
  - provide information (e.g., on STEM careers)

- **Large literature on teacher-student gender interactions**
  Canes and Rosen (1995); Bettinger and Long (2005); Dee (2005); Hoffman and Oreopoulos (2009); Carrel et al. (2010)
  - problem: cannot disentangle role model/teaching practices
  - policy implications are unclear (not easily scalable)

- **Limited evidence on effects of external role models**
  - mostly from lab experiments with mixed findings
    Cheryan et al. (2011); Betz and Sekaquaptewa (2012)
  - evidence from the field: scarce and not related to STEM
    Nguyen (2008); Beaman et al. (2012); Porter and Serra (2017)

Research questions

- **Can classroom-based interventions by female external role models influence students' attitudes toward STEM careers?**
  - Holding teaching practices constant
- **Can we change students' choices by changing their beliefs?**
  - What are the key messages to convey? Are some messages counter-productive?
- **To whom are role models relevant?**
  - Can boys be positively affected by female role models?
- **Are different "types" of role models equally effective?**
  - Professional background vs. research-oriented background?

This Paper

- **Large-scale randomized field experiment evaluating classroom interventions in French high schools**
  - one hour in-class intervention by external female role models
  - approx. 20,000 high school students in Grades 10 and 12
  - two types of role models: young professionals / researchers

- **Causal evidence on the impact of external role models on male and female students' attitudes and choice of studies:**
  - attitudes towards STEM careers and gender roles in science
  - academic self-perception and aspirations
  - choice of field of study in year following the intervention

- **Policy relevance:**
  - light-touch interventions that can be easily scaled up
  - how effects vary by characteristics of students/role models

Outline

1. Introduction
2. The Program
3. Experimental Design
4. Data and Empirical Strategy
5. Results
6. Conclusion

Outline

The Program

- **For Girls in Science (FGiS)**: awarness program launched in 2014 by the L'Oréal Corporate Foundation with the aim of encouraging girls to explore STEM career paths

- **Target population:** high school students

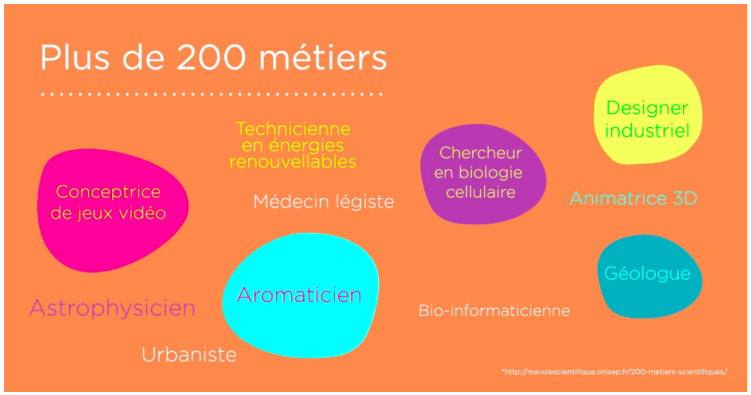
- **Format:** one-hour classroom intervention by trained female facilitators with a background in STEM ("FGiS ambassadors")
  - Professionals: L'Oréal employees who volunteer in the program
  - Young researchers: Ph.D. students/postdocs awarded a L'Oréal-Unesco 'For Women in Science' fellowship; participate in the program as part of their contract

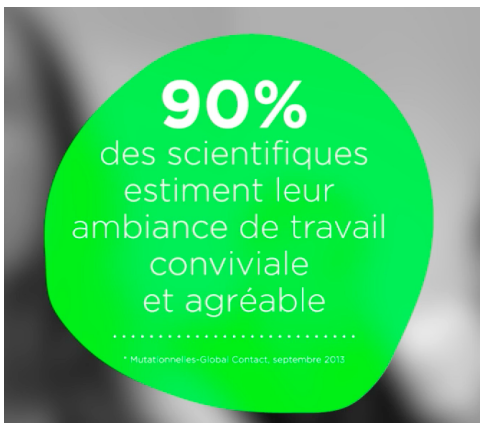
FGiS Ambassadors in 2015 (Ph.D./Postdocs)

Content of Classroom Interventions

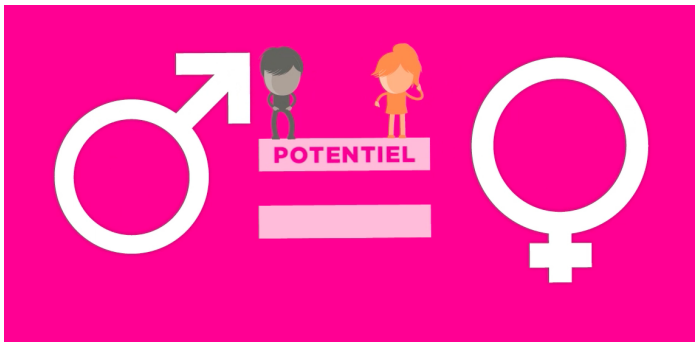
- Introduction with a set of **customizable slides**:
  - STEM jobs in high demand but shortage of graduates
  - under-representation of women in STEM careers
- **Two short videos** to illustrate/deconstruct stereotypical views on science-related careers and gender roles in science:
  - Video 1: "Jobs in Science: Beliefs or Reality?"
  - Video 2: "Are we All Equal in Science?"
- **In-class discussion** building on students' reactions to the videos
- **Question/answer session** drawing upon the facilitator's own experience (e.g., typical day at work, pay, work/family balance)
- Overview of the diversity of **STEM studies and careers**

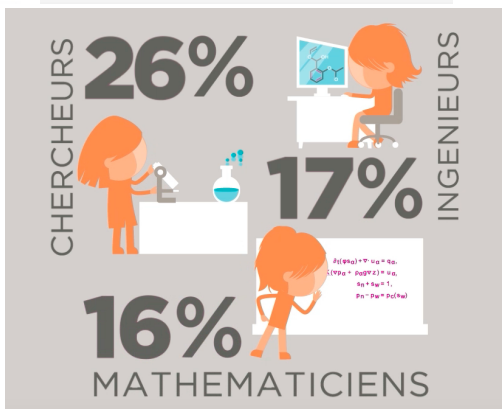
Video 1: “Jobs in Science: Beliefs or Reality?”





Video 2: “Are we All Equal in Science?”





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Experimental Design

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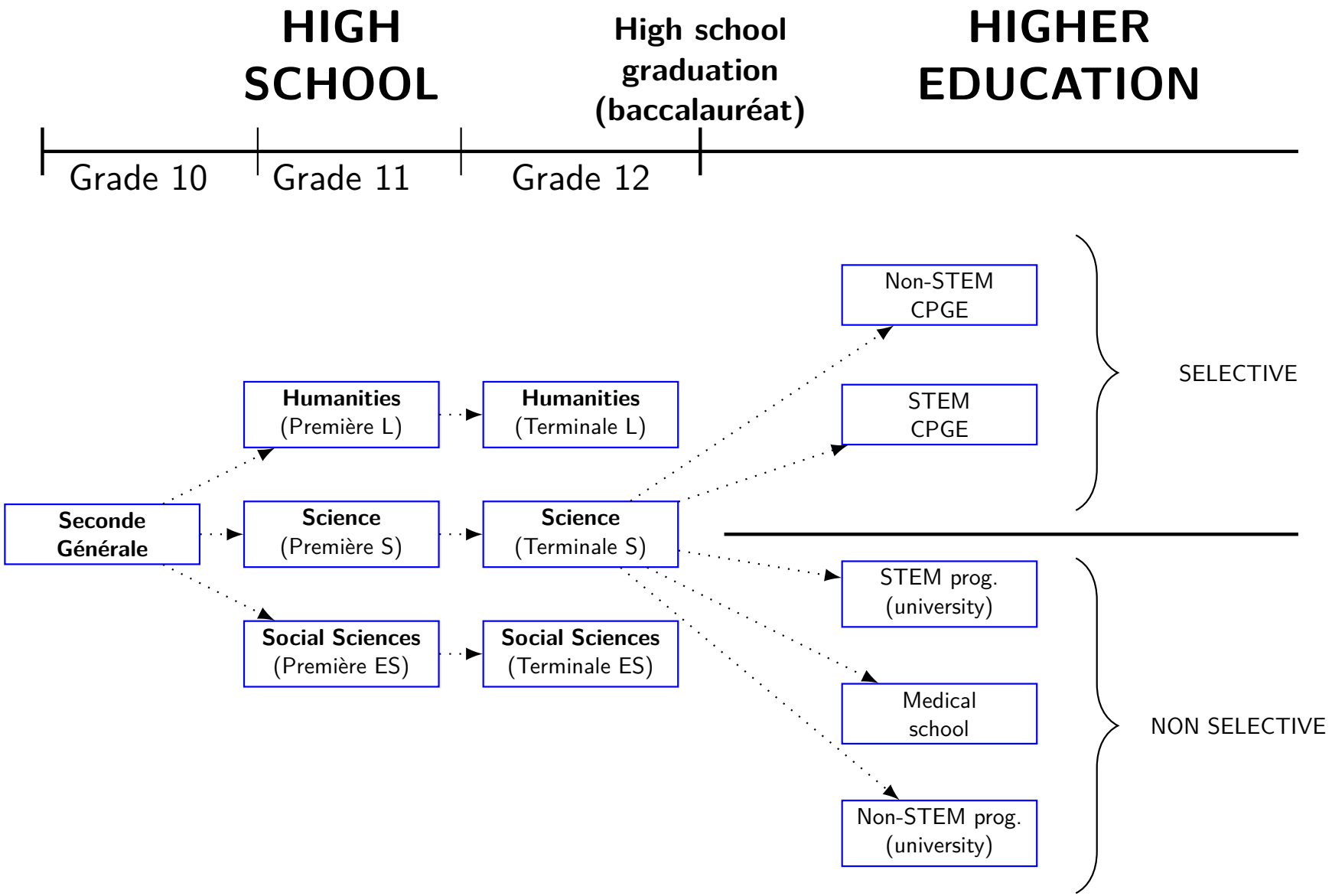
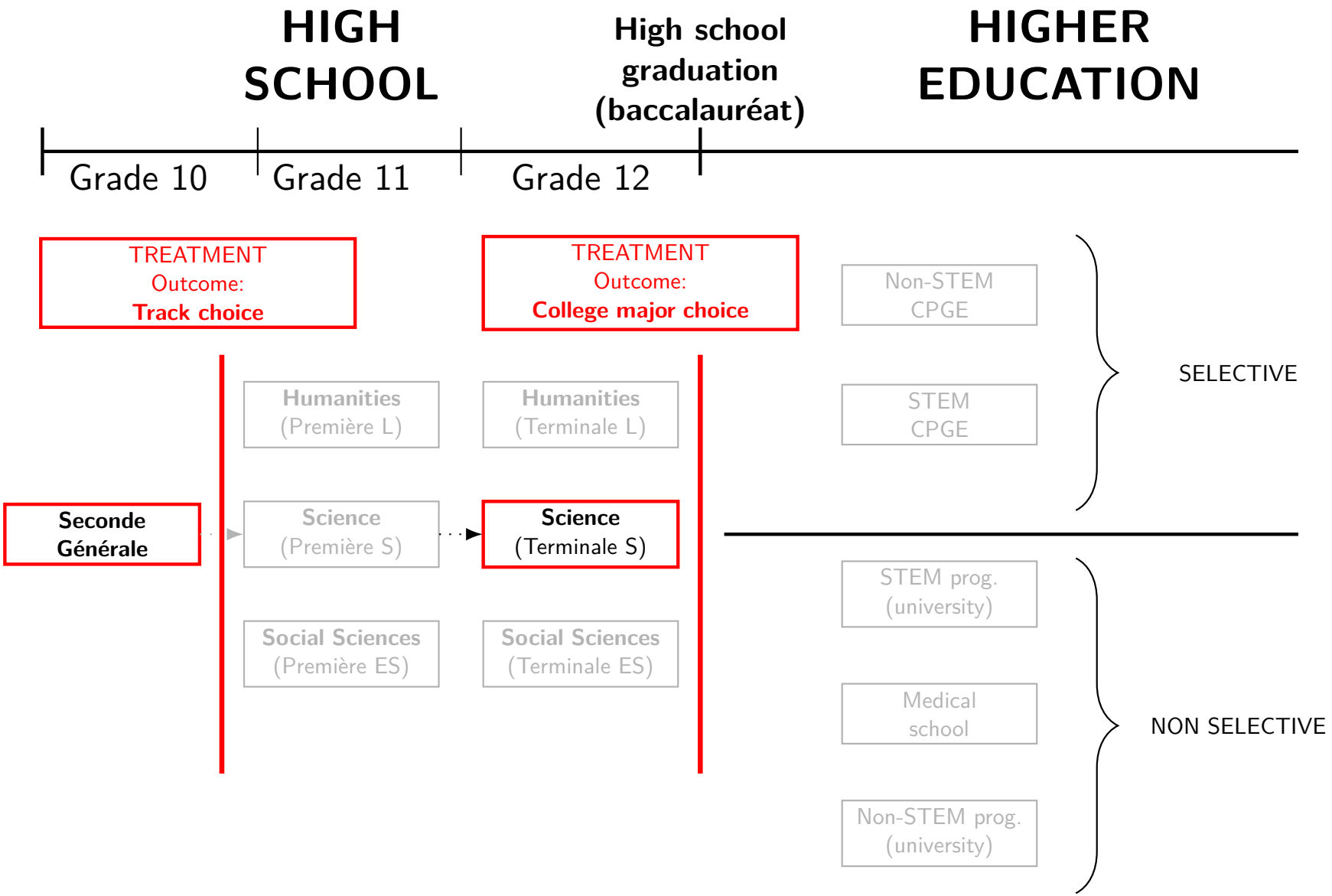
  - conducted during academic year 2015-2016
  - in public and private high schools of the Paris region
  - with the support of the French Ministry of Education
- **Targeted students:**
  - Grade 10 (*Seconde générale et technologique*)
  - Grade 12 - science track (*Terminale scientifique*)


HIGH SCHOOL
High school graduation (baccalauréat)
HIGHER EDUCATION
Grade 10
Grade 11
Grade 12
Seconde Générale
Humanities (Première L)
Humanities (Terminale L)
Science (Première S)
Science (Terminale S)
Social Sciences (Première ES)
Social Sciences (Terminale ES)
Non-STEM CPGE
STEM CPGE
STEM prog. (university)
Medical school
Non-STEM prog. (university)
SELECTIVE
NON SELECTIVE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High school graduation (baccalauréat)
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Grade 10
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TREATMENT
Outcome:
Track choice
TREATMENT
Outcome:
College major choice
Seconde Générale
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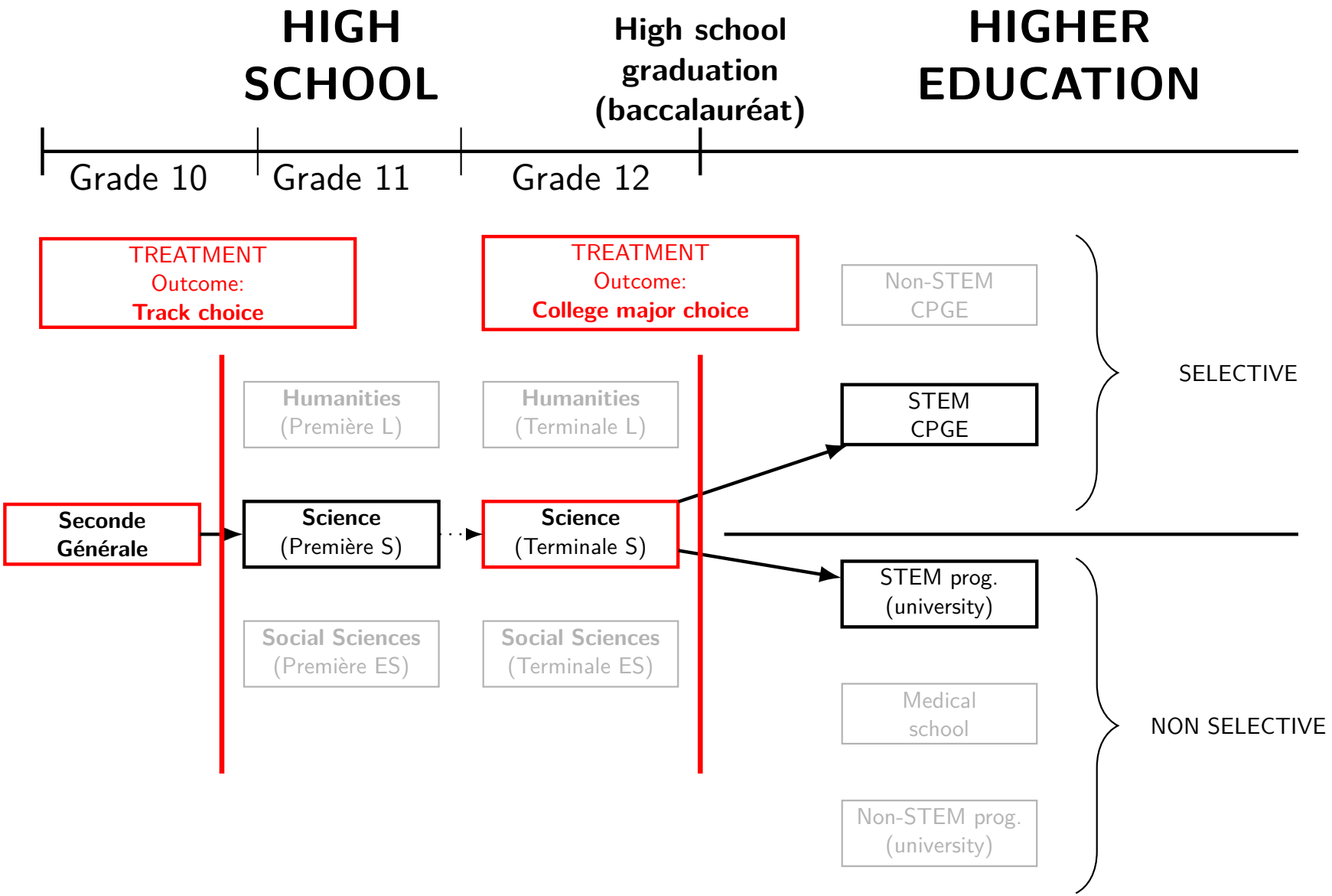
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STEM CPGE
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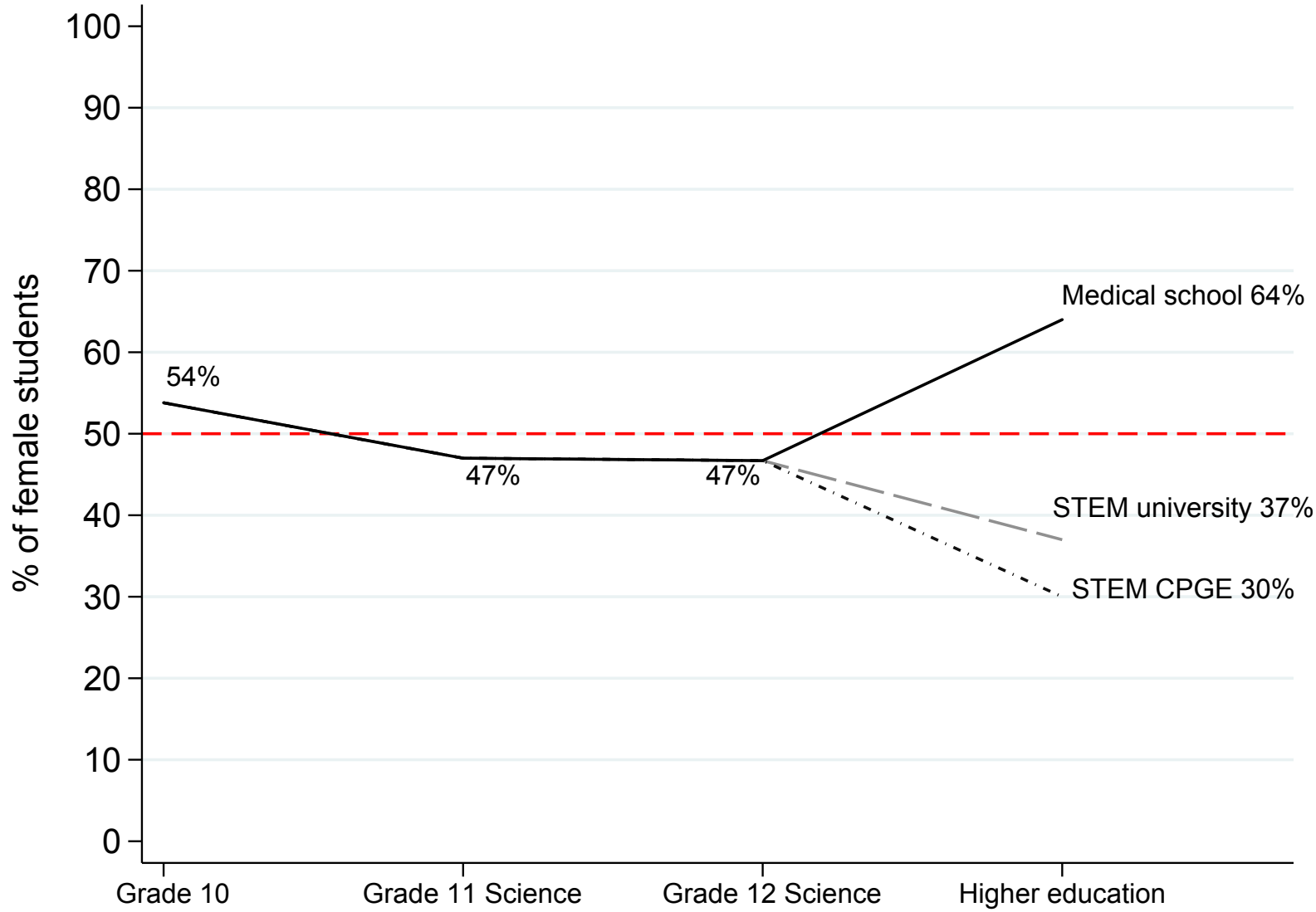
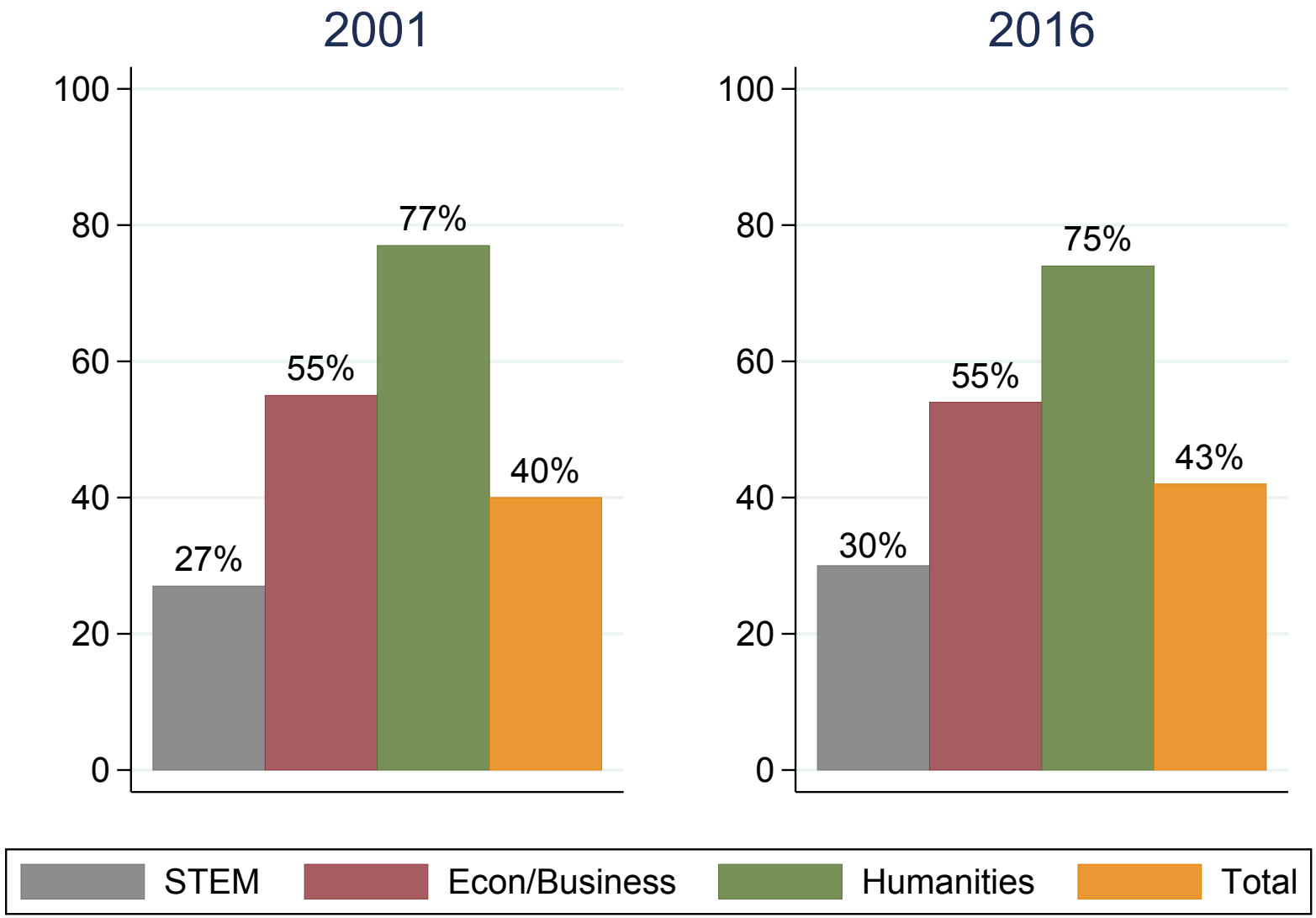
SELECTIVE
NON SELECTIVE

Female Under-Representation in STEM Sudies, France, 2016-2017



Source: MEN-MESRI-DEPP and MESRI-SIES (2018).

Share of Female Students in Selective Undergraduate Programs (CPGE)



Source: MESRI-SIES (2018).

Experimental Design

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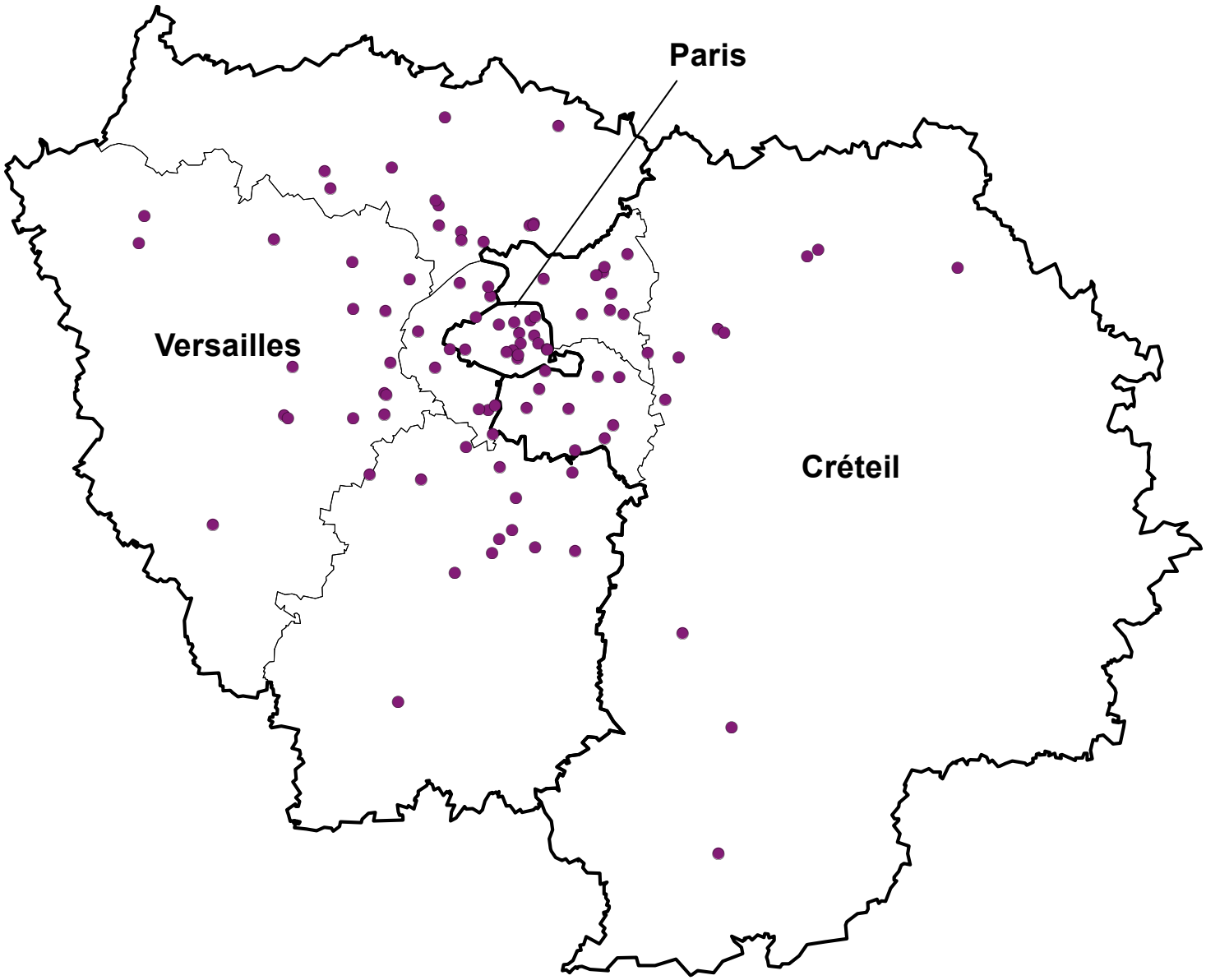
- **Schools selected on a voluntary basis:** 98 participating schools out of the 489 operating in the Paris region Summary statistics

Participating High Schools



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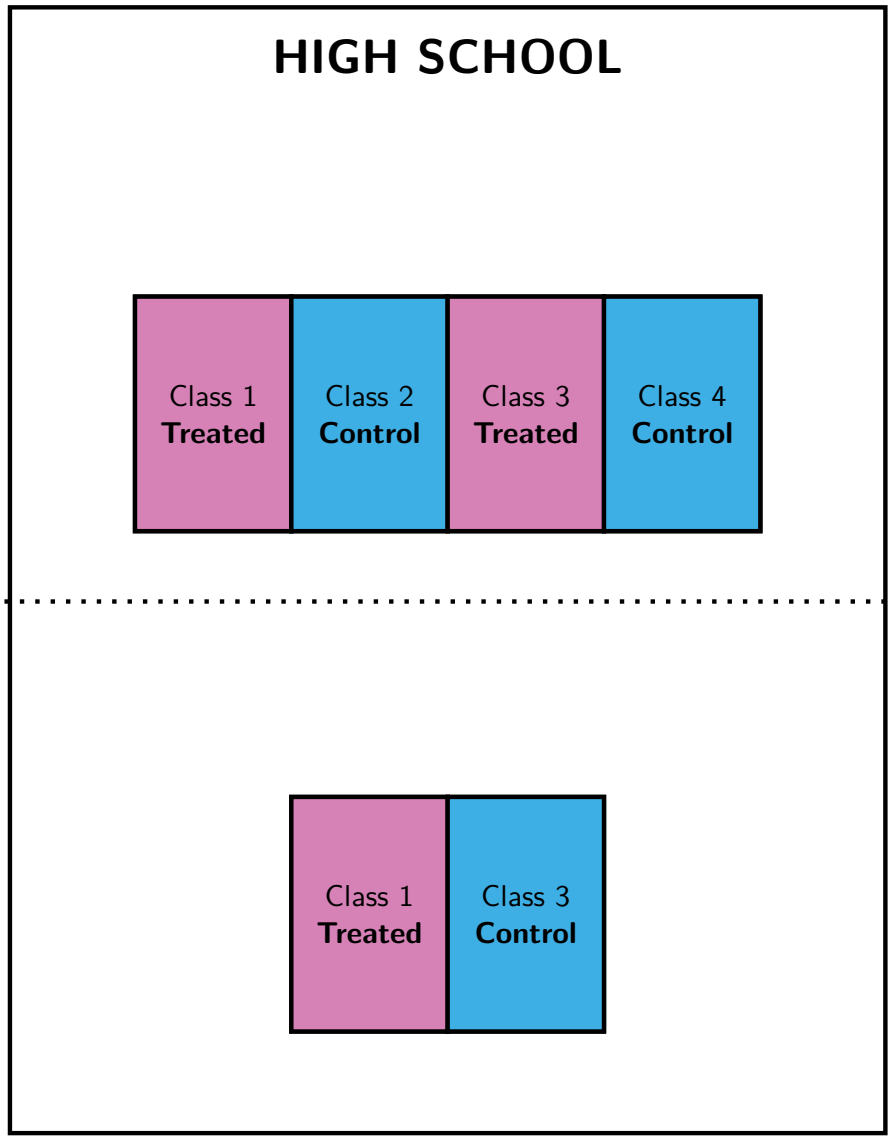
- **Classroom interventions**: Nov 2015 – Feb 2016

Randomization



Grade 10

13,700 students

Grade 12

5,751 students

19,451 students in the experimental sample

302 classes randomly drawn to be visited by facilitator

299 classes served as a the control group

Female Facilitators: Summary Statistics

	All	Professionals	Ph.D/Postdoc
Age (years)	33.3 (5.7)	35.6 (6.0)	30.1 (3.1)
Non-French	0.13	0.14	0.10
Field: Maths, Physics, Engineering	0.23	0.14	0.38
Field: Earth & Life Sciences	0.63	0.66	0.57
Field: other	0.14	0.20	0.05
Has a Ph.D degree	0.55	0.38	0.81
Facilitator the year before	0.25	0.29	0.19
Has children	0.46	0.63	0.19
Number of high schools visited	1.8 (0.8)	1.6 (0.7)	2.1 (0.9)
Number of classroom interventions	5.4 (2.4)	4.9 (2.3)	6.2 (2.5)
N	56	35	21

Notes: Standard deviations in parentheses.

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Data Sources

- **Post-visit ambassador survey**:
  - general feedback questions on classroom interventions
  - used to check compliance with randomization
- **Post-treatment student survey:**
  - 8-page questionnaire administered in exam conditions
  - 1–6 months after intervention
  - Overall response rate: 90% (T−C diff. < 0.03) Response rates
- Matched with **student-level admin data**:
  - socio-demographic info
  - enrollment status in subsequent year
  - exam results in Grade 9 (DNB) and Grade 12 (Baccalauréat)

Empirical Strategy

- Limited non-compliance with random assignment ($< 5\%$ of classes)
- Treatment effects (LATE) estimated separately by gender and grade level using 2SLS:

$$Y_{ics} = \alpha + \beta Visit_{ics} + \theta_s + \epsilon_{ics} \quad (1)$$

$$Visit_{ics} = \gamma + \delta Treat_{ics} + \lambda_s + \eta_{ics} \quad (2)$$

Y_{ics}: outcome of student i in classroom c and high school s
$Treat_{ics}$: treatment assignment dummy
$Visit_{ics}$: classroom visit dummy
θ_s, λ_s: school fixed effects

s.e. clustered at classroom level (unit of randomization)

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Treatment-Control Balance

	Control group	Treatment group	Difference T−C	P-value
Panel A. Grade 10				
Girl	0.534	0.524	−0.010	0.309
Repeater	0.802	0.801	−0.001	0.892
Non-French	0.059	0.061	0.002	0.652
High SES	0.374	0.381	0.007	0.364
Medium-high SES	0.136	0.129	−0.006	0.221
Medium-low SES	0.248	0.235	−0.012	0.064
Low SES	0.243	0.255	0.012	0.085
DNB percentile rank in math	45.09	44.94	−0.147	0.813
DNB percentile rank in French	45.95	46.32	0.378	0.540
Took at least one science elective course	0.391	0.396	0.005	0.820
Took at least one standard elective course	0.769	0.738	−0.031	0.138
N	6,801	6,899		
Test of joint significance	F-stat: 1.530 (p-value: 0.126)			
Panel B. Grade 12 (major in science)				
Girl	0.498	0.485	−0.014	0.292
Repeater	0.745	0.767	0.021	0.023
Non-French	0.054	0.048	−0.006	0.275
High SES	0.441	0.470	0.029	0.008
Medium-high SES	0.144	0.143	−0.001	0.826
Medium-low SES	0.216	0.201	−0.015	0.023
Low SES	0.198	0.186	−0.012	0.140
DNB percentile rank in math	62.04	62.42	0.388	0.547
DNB percentile rank in French	59.03	59.93	0.901	0.172
N	2,853	2,898		
Test of joint significance	F-stat: 1.570 (p-value: 0.136)			

Outcomes of Interest

- **Students' general perceptions**
  - about science-related careers
  - about gender roles in science
- **Students' self-perceptions and interests**
  - interest in science subjects
  - self-concept in math
  - interest in science-related careers
- **Enrollment outcomes (admin data)**
  - Grade 10 students: high school track in Grade 11
  - Grade 12 students: choice of college major

Perceptions of Science-Related Careers

	Girls		Boys	
	C	T−C	C	T−C
Panel A : Grade 10				
Negative perceptions of science-related careers (index)	**0.016**	**−0.245*** **	**−0.032**	**−0.167*** **
Studies in science are lengthy	0.839	−0.087***	0.848	−0.074***
Jobs in science are dreary	0.288	−0.032**	0.318	−0.006
Jobs in science are solitary	0.325	−0.061***	0.298	−0.062***
Higher wages in science	0.641	0.008	0.666	0.015
Hard to maintain work-life balance	0.295	−0.026**	0.279	−0.029**
N		6,475		5,751
Panel B : Grade 12 (science track)				
Negative perceptions of science-related careers (index)	**0.011**	**−0.312*** **	**0.005**	**−0.155*** **
Studies in science are lengthy	0.669	−0.110***	0.724	−0.091***
Jobs in science are dreary	0.171	−0.019	0.237	−0.026
Jobs in science are solitary	0.233	−0.088***	0.206	−0.047***
Higher wages in science	0.529	0.059**	0.574	0.027
Hard to maintain work-life balance	0.225	−0.049**	0.168	−0.012
N		2,600		2,636

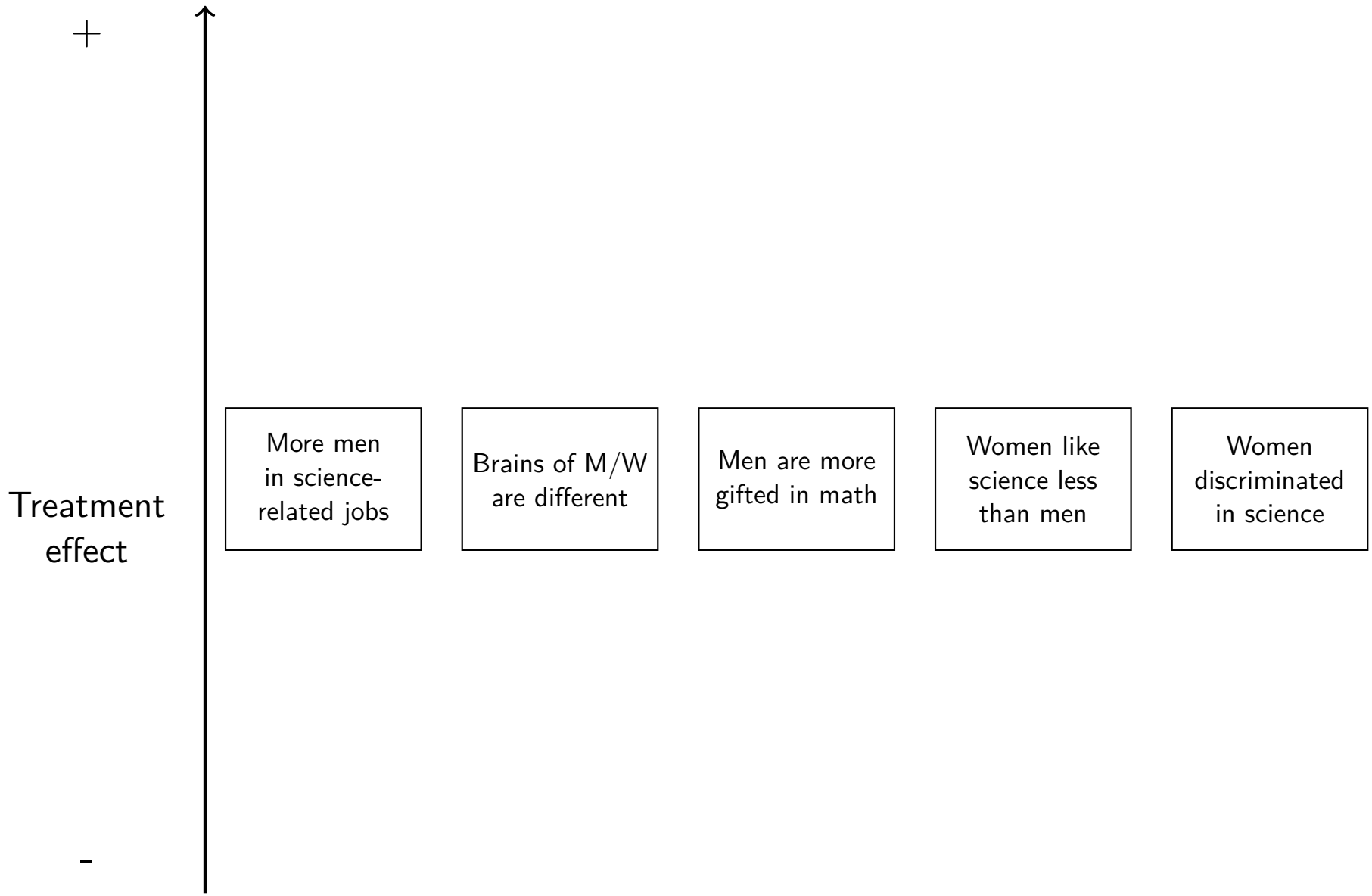
Notes: *** p<0.01; ** p<0.05; * p<0.1.

Perceptions of Gender Roles in Science

	Girls		Boys	
	C	T−C	C	T−C
Panel A : Grade 10				
More men in science-related jobs	0.629	0.156***	0.630	0.168***
Brains of M/W are different at birth	0.212	−0.050***	0.208	−0.048***
Men are more gifted in math	0.187	−0.026**	0.301	−0.048***
Women like science less than men	0.162	0.059***	0.200	0.103***
Women are discriminated in STEM careers	0.603	0.127***	0.525	0.153***
N		6,475		5,751
Panel B : Grade 12 (science track)				
More men in science-related jobs	0.714	0.125***	0.722	0.149***
Brains of M/W are different at birth	0.146	−0.023	0.177	−0.038**
Men are more gifted in math	0.160	−0.038**	0.265	−0.028
Women like science less than men	0.073	0.044***	0.148	0.073***
Women are discriminated in STEM careers	0.625	0.095***	0.600	0.072***
N		2,600		2,636

Notes: *** $p<0.01$; ** $p<0.05$; * $p<0.1$.

Interpretation



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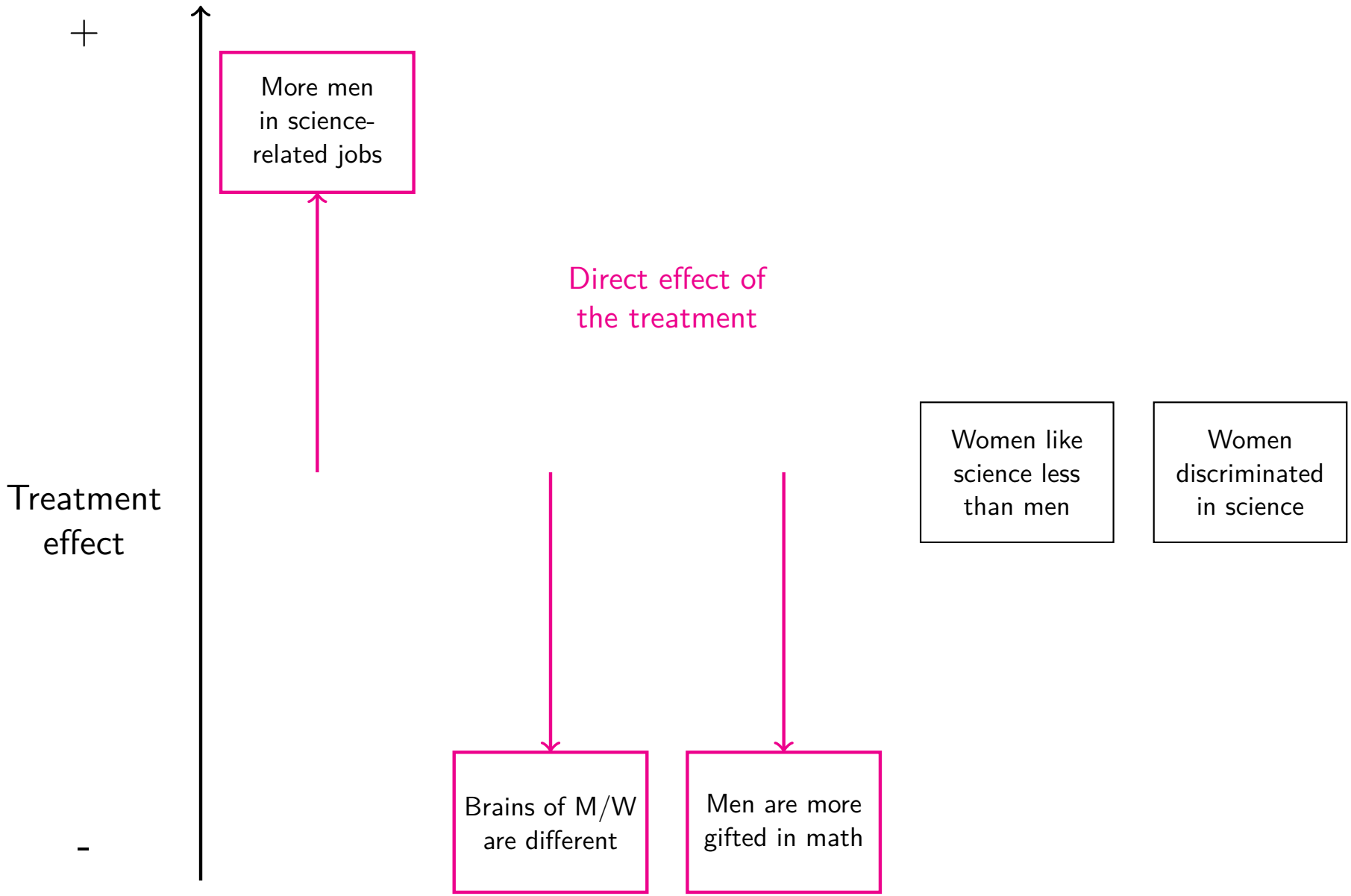

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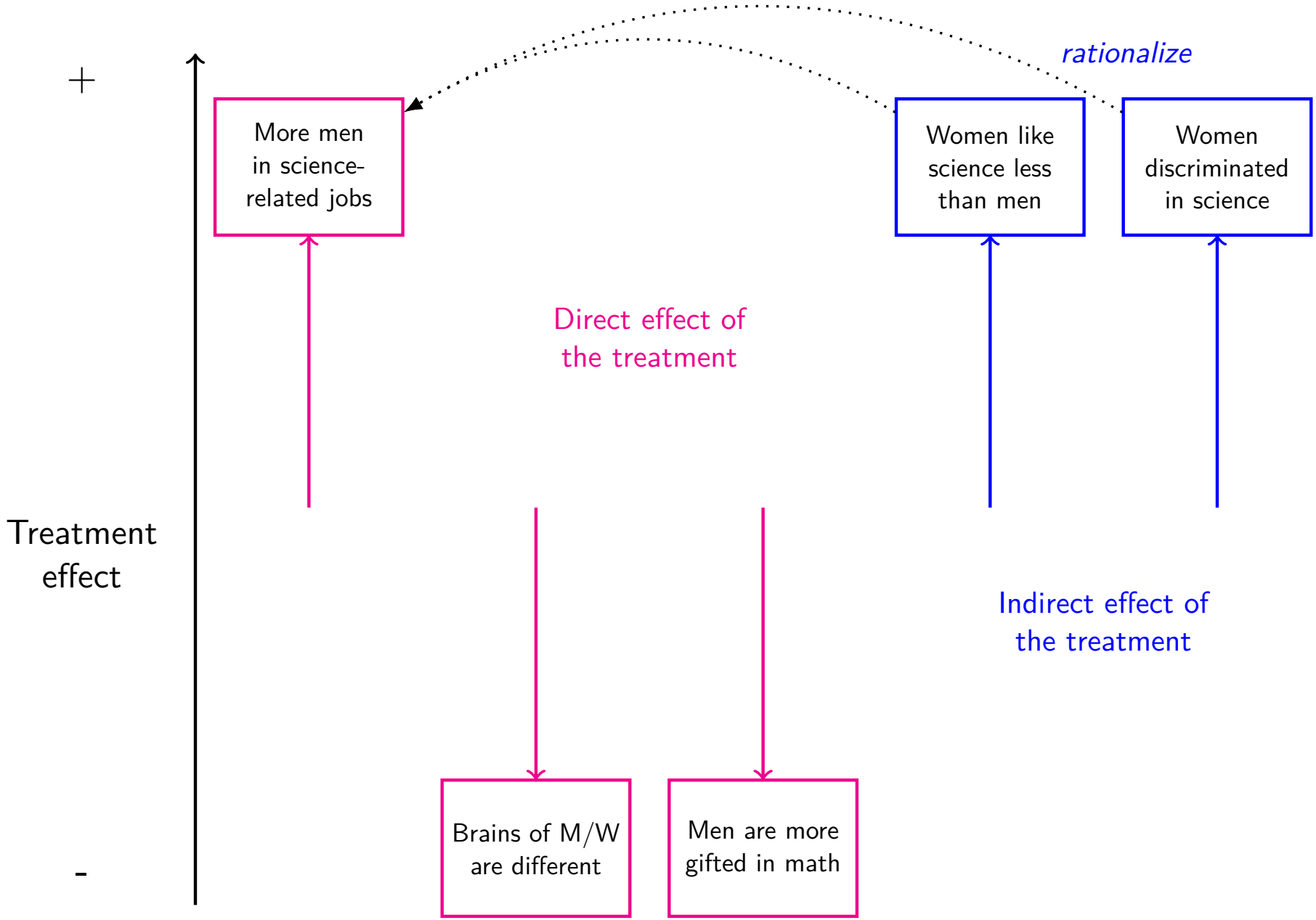


Interest in Science

	Girls		Boys	
	C	T−C	C	T−C
Panel A : Grade 10				
Interest in science (index)	**−0.191**	**−0.038**	**0.190**	**−0.019**
Enjoys math (*z*-score)	−0.161	−0.002	0.186	−0.002
Enjoys physics-chemistry (*z*-score)	−0.189	−0.040	0.218	−0.022
Enjoys biology-geoscience (*z*-score)	−0.064	−0.058	0.074	−0.027
Enjoys science : Agree	0.657	−0.011	0.789	0.003
N		6,475		5,751
Panel B : Grade 12 (science track)				
Interest in science (index)	**−0.005**	**0.016**	**0.000**	**0.000**
Enjoys math (*z*-score)	−0.101	0.067*	0.102	0.075*
Enjoys physics-chemistry (*z*-score)	−0.088	−0.001	0.090	−0.021
Enjoys biology-geoscience (*z*-score)	0.199	−0.030	−0.207	−0.059
Enjoys science: Agree	0.918	−0.001	0.929	0.013
N		2,600		2,636

Notes: *** p<0.01; ** p<0.05; * p<0.1.

Self-Concept in Math

	Girls		Boys	
	C	T−C	C	T−C
Panel A : Grade 10				
Low math self-concept (index)	**0.212**	**0.008**	**−0.235**	**−0.039**
Self-assessed performance in math (*z*-score)	−0.157	−0.017	0.164	0.022
Lost in front of a math problem	0.557	0.010	0.343	−0.007
Worried when thinking about math	0.622	−0.025*	0.416	−0.032**
Can do well in science subjects if puts enough effort	0.842	0.018	0.884	−0.004
N		6,475		5,751
Panel B : Grade 12 (science track)				
Low math self-concept (index)	**0.182**	**−0.050**	**−0.191**	**−0.072****
Self-assessed performance in math (*z*-score)	−0.127	0.039	0.130	0.079**
Lost in front of a math problem	0.488	−0.028	0.325	−0.028
Worried when thinking about math	0.556	−0.037**	0.379	−0.051***
Can do well in science subjects if puts enough effort	0.941	−0.005	0.951	0.006
N		2,600		2,636

Notes: *** p<0.01; ** p<0.05; * p<0.1.

Interest in Science-Related Careers

	Girls		Boys	
	C	T−C	C	T−C
Panel A : Grade 10				
Interest in science-related careers (index)	**−0.118**	**0.017**	**0.145**	**0.010**
Some jobs in science are interesting	0.844	0.019**	0.855	0.000
Would consider a job in science	0.463	−0.004	0.588	0.023*
Interested in at least one of listed STEM jobs[1]	0.496	0.022	0.805	0.021*
Wages important in choice of studies (*z*-score)	−0.041	−0.012	0.047	0.007
N		6,475		5,751
Panel B : Grade 12 (science track)				
Interest in science-related careers (index)	**−0.065**	**0.116*** **	**0.067**	**0.050**
Some jobs in science are interesting	0.961	0.013**	0.938	0.021***
Would consider a job in science	0.716	0.031**	0.764	0.030**
Interested in at least one of listed STEM jobs[1]	0.638	0.012	0.844	0.006
Wages important in choice of studies (*z*-score)	−0.040	0.119**	0.041	0.049
N		2,600		2,636

Notes: [1]: computer scientist, engineer, renewable energies technician, industrial designer.
*** p<0.01; ** p<0.05; * p<0.1.

Grade 10 Students – STEM Enrollment in Grade 11

	Girls			Boys		
	C	T−C	*p*-value	C	T−C	*p*-value
Total STEM tracks						
Grade 11 : science track	0.363	−0.008	0.586	0.576	−0.006	0.676
General/technical STEM tracks						
Grade 11: general science track	0.336	−0.002	0.888 [0.889]	0.432	0.004	0.773 [0.774]
Grade 11: technical science track	0.027	−0.006	0.112 [0.224]	0.145	−0.010	0.235 [0.470]
N		7,241			6,459	

Notes: *** p<0.01; ** p<0.05; * p<0.1. FDR adjusted *p*-values (*q*-values) are in brackets.

Grade 12 Students – STEM Enrollment after High School Graduation

	Girls			Boys		
	C	T−C	*p*-value	C	T−C	*p*-value
Total STEM undergraduate programs						
STEM program	0.282	0.024*	0.195	0.468	0.003	0.916
Selective vs. non-selective STEM						
Selective STEM (CPGE)	0.109	0.035***	0.025 [0.050]	0.231	0.020	0.335 [0.495]
Non-selective STEM (University)	0.173	−0.011	0.459 [0.459]	0.237	−0.017	0.371 [0.495]
Male- vs. female-dominated STEM						
Male-dominated STEM (math, physics, computer science)	0.165	0.038***	0.022 [0.050]	0.377	0.017	0.517 [0.517]
Female-dominated STEM (earth & life sciences)	0.118	−0.015	0.292 [0.390]	0.091	−0.014	0.259 [0.495]
N		2,827			2,924	

Notes: *** p<0.01; ** p<0.05; * p<0.1. Adjusted *p*-values (*q*-values) are in brackets.

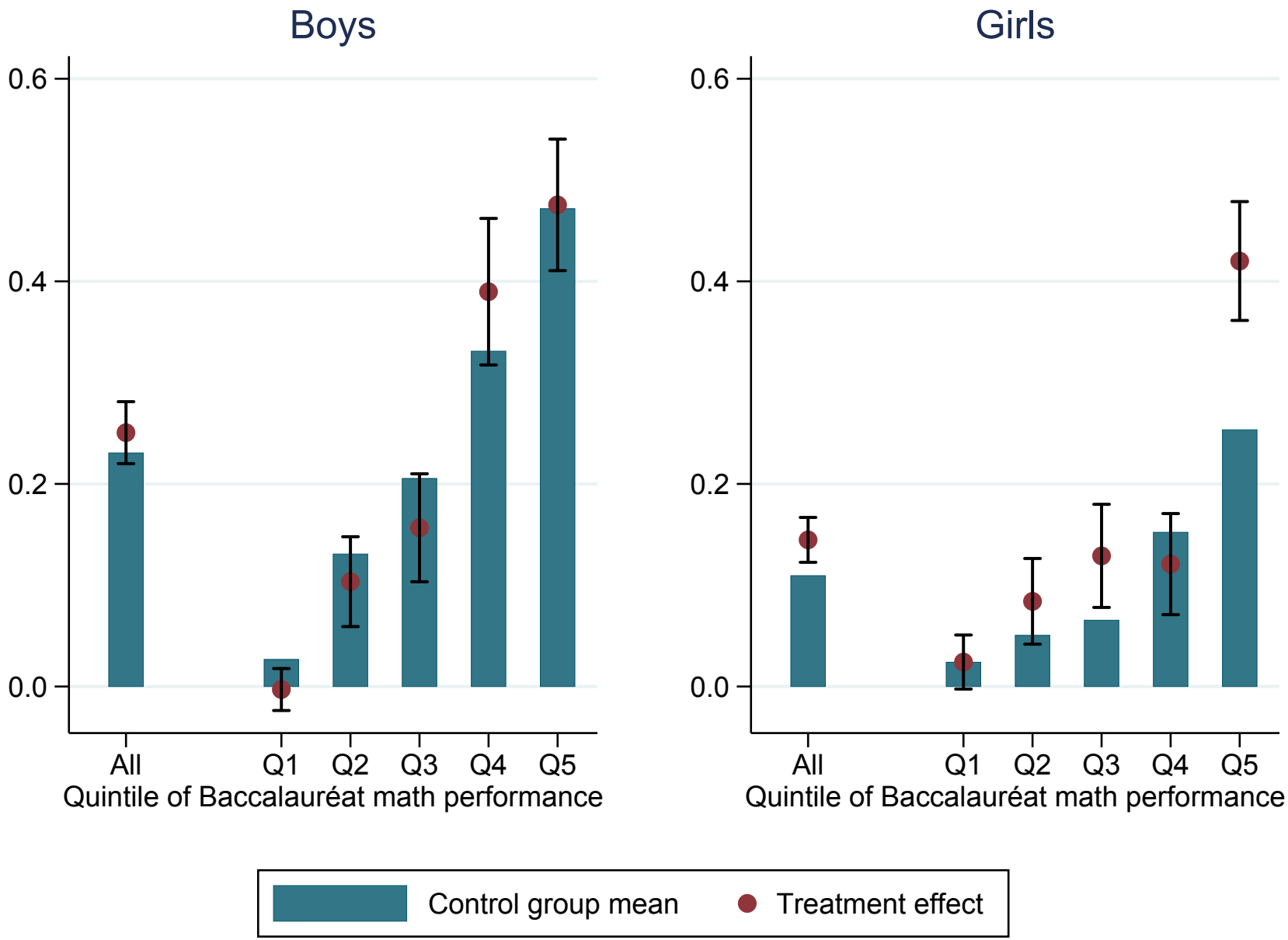
→ one girl in every two classes switching to selective/male-dominated STEM

Heterogeneity in STEM Enrollment Outcomes

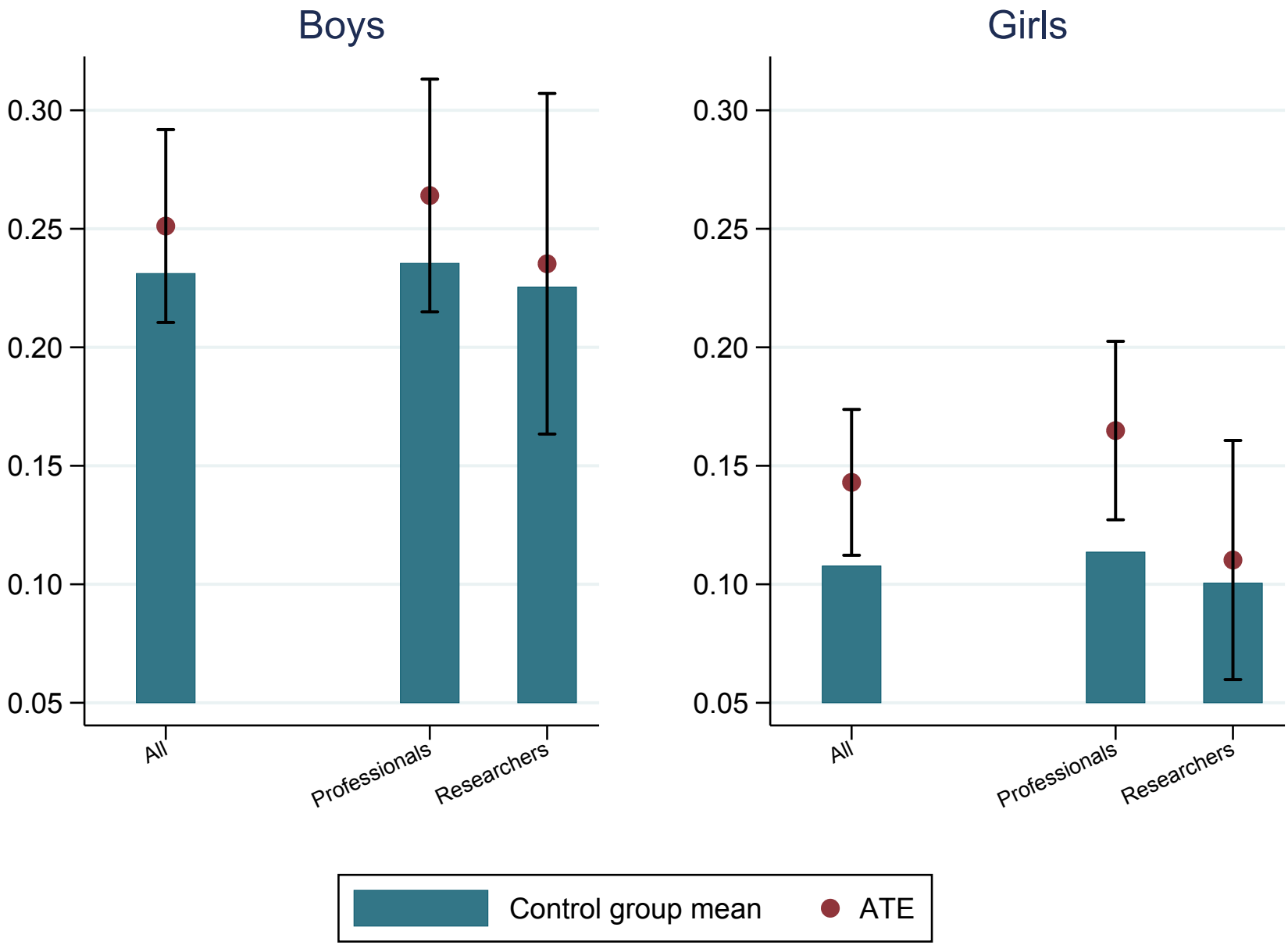
- Investigate heterogeneity of STEM enrollment effects among Grade 12 students along **two dimensions**:
  - by student academic performance in math
  - by facilitator "type": professional vs. research background

- **Results:**
  - enrollment effects in Grade 12 driven by high-achieving girls
  - professionals had larger effects than young researchers

Grade 12: Enrollment in Selective STEM, by Math Performance



Grade 12: Enrollment in Selective STEM, by Type of Female Facilitator



Heterogeneity: Potential Channels

- **Heterogenous effects by student performance in math** Table
  - high achievers more responsive to "positive" messages: studies in STEM not necessarily long, equal aptitude of women/men
  - lower-performing students more likely to perceive gender discrimination in STEM careers
  - high-achieving G12 girls more likely to report being interested in science-related jobs and to consider wages as important

- **Heterogenous effects by type of female facilitator** Table
  - professionals more effective than researchers at increasing Grade 12 girls' interest in STEM careers
  - potential mediator: information on STEM careers and wages
  - perceived are more attainable/attractive role models?

Conclusion

- **A one-hour intervention by external female role models can affect students' attitudes and choice of studies**
  - significant effects on male and female students' perceptions of STEM careers and of gender roles in science
  - among high-achieving girls in Grade 12, increased probability of enrolling in selective / male-dominated STEM
- **Evidence that one size may not fit all**
  - increasing the salience of gender disparities in STEM can have indirect effects on the perception of gender discrimination
  - role models might not be relevant for all students
  - the "type" of role models matters
- **Ongoing research:** use ML techniques to investigate mechanisms
  - heterogeneity in treatment effects
  - correlation between effects on different outcomes

Can Female Role Models Reduce the Gender Gap in Science? Evidence from Classroom Interventions in French High Schools

Thomas Breda
CNRS and PSE

Julien Grenet
CNRS and PSE

Marion Monnet
PSE

Clémentine Van Effenterre
Harvard Kennedy School

CEPR/IZA Annual Symposium in Labour Economics – Paris, 20-21 September 2018

Heterogenous Effects by Student Performance in Math

	Girls			Boys		
	below median	above median	p-value of diff.	below median	above median	p-value of diff.
Panel A : Grade 10						
Studies in science are lengthy	−0.041***	−0.125***	0.000	−0.059***	−0.086***	0.228
Men are more gifted in math	−0.009	−0.039***	0.129	−0.035	−0.060***	0.382
Women are discriminated in STEM careers	0.172***	0.088***	0.001	0.173***	0.136***	0.185
Interest in science-related careers (index)	−0.048	0.072*	0.033	−0.025	0.044	0.218
N	3,534	3,707		3,148	3,311	
Panel B : Grade 12						
Studies in science are lengthy	−0.076***	−0.140***	0.099	−0.079***	−0.101***	0.588
Men are more gifted in math	−0.026	−0.049***	0.479	0.000	−0.051**	0.132
Women are discriminated in STEM careers	0.112***	0.080***	0.415	0.084***	0.062***	0.578
Interest in science-related careers (index)	0.075	0.155***	0.316	0.063	0.040	0.780
N	1,345	1,482		1,380	1,544	

Notes: *** p<0.01; ** p<0.05; * p<0.1.

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Heterogenous Effects by Type of Female Facilitator

	Girls			Boys		
	Facilitator: Researcher	Facilitator: Professional	p-value of diff.	Facilitator: Researcher	Facilitator: Professional	p-value of diff.
Panel A : Grade 10						
Negative perceptions of science-related careers (index)	−0.207***	−0.265***	0.420	−0.130**	−0.190***	0.424
Interest in science-related careers (index)	0.018	0.026	0.913	−0.019	0.039	0.379
Higher wages in science	0.029	−0.009	0.282	−0.004	0.026	0.345
Wages important in choice of studies (*z*-score)	−0.018	−0.009	0.282	−0.004	0.026	0.345
Hard to maintain work-life balance	−0.017	−0.039	0.680	−0.002	−0.047**	0.175
N	3,237	4,004		2,890	3,569	
Panel B : Grade 12						
Negative perceptions of science-related careers	−0.201***	−0.379***	0.113	−0.142**	−0.176***	0.715
Interest in science-related careers (index)	−0.104	0.263***	0.000	0.031	0.070	0.707
Higher wages in science	−0.006	0.098***	0.041	0.061*	0.004	0.236
Wages important in choice of studies (*z*-score)	−0.069	0.234***	0.003	0.059	0.045	0.881
Hard to maintain work-life balance	−0.029	−0.059*	0.497	−0.004	−0.024	0.570
N	1,180	1,647		1,312	1,612	

Notes: *** p<0.01; ** p<0.05; * p<0.1.

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Experimental Sample – Summary Statistics

		Experimental sample	
	Paris region (1)	Participating classes (2)	Non-participating classes (3)
Number of high schools	489	98	96
Share private	0.22	0.17	0.08
Panel A. Grade 10			
Number of students	115,720	13,700	19,147
Number of classes	3,627	416	592
Female	0.53	0.53	0.52
Age (years)	15.14	15.13	15.14
High SES	0.40	0.38	0.36
Medium-high SES	0.12	0.13	0.13
Medium-low SES	0.24	0.24	0.25
Low SES	0.24	0.25	0.26
DNB percentile rank in math	57.69	58.48	55.10
DNB percentile rank in French	57.23	57.85	55.75
Panel B. Grade 12 (science track)			
Number of students	38,582	5,751	5,623
Number of classes	1,267	185	179
Female	0.46	0.49	0.42
Age (years)	17.11	17.12	17.10
High SES	0.52	0.46	0.53
Medium-high SES	0.12	0.14	0.13
Medium-low SES	0.20	0.21	0.18
Low SES	0.16	0.19	0.16
DNB percentile rank in math	76.25	74.06	76.20
DNB percentile rank in French	70.78	69.61	69.78

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Student Survey: Response Rates

	Control group	Treatment group	*p*-value
Panel A. Grade 10			
Survey response rate	0.879	0.905	0.005
N	6,801	6,899	
Panel B. Grade 12 (science track)			
Survey response rate	0.908	0.913	0.693
N	2,853	2,898	

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Respondents to the Student Survey: Treatment-Control Balance

	Control group	Treatment group	Difference T−C	P-value
Panel A. Grade 10				
Female	0.537	0.523	−0.014	0.208
Age	15.12	15.11	−0.009	0.345
Non-French	0.057	0.060	0.003	0.542
Receives a scholarship	0.106	0.114	0.008	0.166
High SES	0.380	0.384	0.004	0.689
Medium high SES	0.136	0.132	−0.005	0.408
Medium low SES	0.245	0.236	−0.009	0.284
Low SES	0.239	0.249	0.010	0.192
Percentile rank DNB in math	45.58	45.67	0.083	0.917
Percentile rank DNB in French	46.44	46.79	0.354	0.586
N	5,981	6,245		
Test of joint significance	F-stat:	1.085	p-value:	0.385
Panel B. Grade 12 (major in science)				
Female	0.504	0.490	−0.014	0.449
Age	17.13	17.09	−0.045	0.014
Non-French	0.053	0.045	−0.008	0.272
Receives a scholarship	0.134	0.118	−0.016	0.080
High SES	0.436	0.476	0.039	0.015
Medium high SES	0.147	0.145	−0.001	0.891
Medium low SES	0.219	0.196	−0.022	0.020
Low SES	0.198	0.186	−0.016	0.203
Percentile rank DNB in math	62.43	62.53	0.092	0.924
Percentile rank DNB in French	59.35	60.03	0.675	0.468
N	2,853	2,898		
Test of joint significance	F-stat:	1.473	p-value:	0.171