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FACULTY GENDER AND STUDENT PERFORMANCE IN MALE- AND FEMALE-DOMINATED CAREERS

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Faculty Gender and Student Performance in Male- and Female-dominated Careers*

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Abstract

This paper assesses the effect of teacher gender on the academic performance of students in higher education, considering male- and female-dominated careers. We use rich administrative records of students, teachers and classes from a private university in Chile over a ten-year period. By focusing on first-semester students and estimating fixed-effects models to achieve identification, our findings indicate that teacher gender has an impact on grades. In female-dominated careers, only female students exhibit a positive effect (0.112 SD) from having a female teacher, in comparison to a male teacher. In male-dominated careers however, female teachers have a greater impact on student performance, improving female and male students' grades by 0.286 SD and 0.185 SD, respectively. Moreover, the positive effect of female teachers seems to be more pronounced in larger classes, and among high-achievement students. The discrepancy in effects across gender categories suggests a nuanced interplay of teacher bias and role model, with female teachers potentially favoring female students and serving as aspirational figures for girls.

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1 Introduction

Despite the substantial historical and global efforts to reduce gender inequalities, gender gaps continue to persist, evidenced by women's limited access to quality employment and enduring wage disparities (World Economic Forum, 2023). Gaps are particularly pronounced in STEM fields. Women pursuing careers in these fields are less likely to work in high-paying, male-dominated sectors compared to men (Aguirre et al., 2020).

This phenomenon has been extensively studied and can be attributed to various factors such as deeply ingrained gender stereotypes in society (Carrell et al., 2010; Gong et al., 2018), biases (Hoffmann and Oreopoulos, 2009; Lavy and Sand, 2018), a shortage of female role models in fields predominantly represented by men (Paredes, 2014; Hand et al., 2017), preferences in the workplace (Zafar, 2013), self-concept or perception of abilities (Lindberg et al., 2013; Sansone, 2019), and gender-related social norms (Nollenberger and Rodríguez-Planas, 2017).

According to UN Women, one of the contributing factors to the gender wage gap is the disproportionate representation of women in lower-paying sectors (International Labour Organization, 2019). This indicates a prevailing pattern where women tend to opt for careers and fields historically dominated by females. Unfortunately, these sectors often offer fewer salaries compared to those predominantly occupied by men. Historically, women have been associated with roles in care-giving, teaching, or healthcare, which typically offer lower wages than fields such as engineering, technology, or finance, which have been predominantly represented by men.

In Chile, and of the most OECD countries, women's enrollment in higher education exceeds that of men (OECD, 2022). However, in terms of chosen fields, evidence shows that women are underrepresented in STEM fields while they are overrepresented in humanities, education, health, and arts (Bettinger and Long, 2005; Zafar, 2013; Bordón et al., 2020). This underrepresentation of women can have broad implications for women's educational benefits and may be related to occupational segregation and gender wage inequality.

From the early stages of schooling, differences in student performance are observed, with girls typically excelling in reading and boys in mathematics. These differences may contribute to the perception of traditional gender roles. Given that students spend a significant part of their day with their teachers, it is reasonable to assume that faculty members influence students' development and preferences (Brenøe and Zölitz, 2020).

In male-dominated fields, there's a legitimate concern about the potential creation of a hostile environment for female students. This concern arises from multiple factors, primarily rooted in deeply ingrained gender stereotypes that can lead to biases and negative perceptions of women in these fields. Additionally, the underrepresentation of women in leadership roles and the lack of female role models reinforce these stereotypes, while implicit biases further impact how women are treated (International Labour Organization, 2019). Conversely, in female-dominated fields, men may face challenges due to the reversal of traditional gender roles, which can lead to stereotypes viewing them as atypical. These challenges include societal expectations and lack of role models.

Several studies have documented the effect of teacher gender on students at different educational levels, in primary school (Paredes, 2014; Antecol et al., 2015; Gong et al., 2018; Lindberg et al., 2013), secondary school (Rakshit and Sahoo, 2023; Dee, 2007; Winters et al., 2013; Sansone, 2019; Lim and Meer, 2017; Lavy and Sand, 2018; Holmlund and Sund, 2008), and at the university/post-secondary level (Carrell et al., 2010; Hoffmann and Oreopoulos, 2009).

In particular, Hoffmann and Oreopoulos (2009) investigate gender interactions between professors and first-year undergraduate students at the University of Toronto, and find that teacher gender has a limited impact on academic performance and interest in subjects. Students taught by a professor of the same gender have a slightly lower probability of dropping a course and achieve slightly better grades compared to those taught by a professor of the opposite gender; effects that appear to be primarily driven by low performance students.

On the other hand, Carrell et al. (2010) examine the impact of teacher gender on students' performance in STEM courses at the US Air Force Academy. With a quasi-experimental approach, the authors find that teacher gender exerts a considerable influence on female students' performance in mathematics and science subjects, as well as their likelihood of pursuing STEM careers in the future and graduating with degrees in these fields. They state that women are less likely to continue in STEM careers after taking classes with teachers of the opposite gender, supporting the idea that the lack of female role models in these courses can perpetuate the gender gap.

In this paper, we contribute to the literature by estimating the impact of teacher gender on the immediate academic performance of students in higher education, considering three gender-specific career contexts: male-dominated careers such as STEM fields, female-dominated careers such as Health and Education, and gender-balanced careers such as Law and Business. We use administrative records from *Universidad de los Andes*, a Chilean private university offering bachelor degrees in several fields. We have access to student level information such as socioeconomic and high school academic variables, along with final grades and class characteristics for every course they take. In addition, we also have access to individual teacher characteristics that allow us to further isolate the effect of faculty gender on grades.

Our identification strategy relies on the sample restriction to first-year first-semester classes only, given that students lack autonomy in choosing classes, teachers or schedules, as these are automatically assigned by the educational institution. Furthermore, in cases where there are multiple classes of the same course, the assignment of students to each class is randomized. Therefore, this automatic assignment significantly addresses the self-selection of students to teacher gender.

To further reduce identification concerns, we exploit the fact that we observe students in several classes during their first semester and use student fixed effects in our regression models in order to account for the unobserved individual heterogeneity that differs between students but remains constant across classes. Therefore, we interpret the teacher gender effect as causal, under the assumption that, conditional on student fixed effects and observed class and teacher characteristics, remaining idiosyncratic errors are orthogonal to teacher gender.

In male-dominated careers, we find that female teachers have a positive effect on student performance in comparison to male teachers. Male students, on average, increase their grades by 0.185 standard deviations (sd) when taught by a female teacher, while female students see an increase of 0.286 sd. This effect seems to be driven by high-achieving students. In addition, when the proportion of female students in a class is above the median and students have a female teacher, both males and females increase their grades by 0.309 sd and this effect is more pronounced in larger class sizes, with an increase of 0.415 and 0.525 sd for male and female students respectively. These results align with the role model hypothesis given that the low presence of female teachers in STEM fields accentuates the impact of their distinctive characteristics compared to their male colleagues. In terms of teacher characteristics, we find that the positive effect of female teachers is stronger among older teachers who do not hold a doctoral degree.

For female-dominated careers, we find that, overall, only female students seem to benefit from having female teachers with an average increase of 0.112 sd in grades, suggesting a teacher bias channel where female professors might teach female students more effectively and treat male students differently due to stereotypes. However, when analyzing more deeply across different groups of students, we find that both male and female high-achievers experience an improvement of 0.122 sd with female teachers in comparison to male teachers. Again, these results are more concentrated among non-doctoral female teachers, with effects of 0.130 sd and 0.276 sd for male and female students, respectively.

Third, in gender-balanced careers, teacher gender does not have a significant effect on student performance. This discrepancy in effects across gender categories suggests a nuanced interplay of teacher bias and role model, with female professors potentially favoring female students and serving as aspirational figures for girls.

Our paper complements the literature stream on faculty gender effects, by focusing on specific gender-related contexts, showing that gender-dominance in comparison to gender-neutrality in the composition of faculty and enrollees matters when evaluating the effectiveness of teachers. As students navigate their career paths, the influence of teacher gender on academic performance emerges as a pivotal factor. Understanding these dynamics is essential for crafting strategies to foster gender parity and ensure equitable opportunities for women in lucrative, male-dominated fields. By advocating for increased representation of female educators in traditionally male-dominated disciplines, universities can pave the way for bridging gender disparities in STEM fields.

The rest of the article is organized as follows. Section 2 presents the data and descriptive statistics. Section 3 describes the methods used for estimating the effect of teacher gender on academic performance. Section 4 presents the results in full, while in Section 5 we analyze and discuss our findings in depth. Section 6 concludes.

2 Data

2.1 Data Sources and Processing

We use administrative data from *Universidad de los Andes*, a private university in Santiago, Chile. The dataset comprises records covering the entire population of students across courses over a ten-year period, from 2012 to 2022. Each observation in the database represents a specific student-class, providing detailed information about the courses they have taken during a given year and semester.

The distinction between courses and classes is crucial for understanding the data. A course is a program of instruction in a particular subject, for example "Chemistry", which remains constant over time. A class, on the other hand, is a specific group of students meeting regularly to study a course under the guidance of the teacher. This distinction is also made by Hoffmann and Oreopoulos (2009) in his study. For instance, "Chemistry" may be offered with different classes each year. In 2018, there were two classes: "Chemistry - Section 1, 2018" and "Chemistry - Section 2, 2018". Each of these classes had its own set of students and teachers, and students received grades based on their performance. In 2019, the offering expanded to three classes: "Chemistry - Section 1, 2019", "Chemistry - Section 2, 2019", and "Chemistry - Section 3, 2019". Each class represents a unique learning experience for students, with distinctive features in terms of faculty, class dynamics, and grades.

Each year, information is available regarding the courses offered in the first and second semesters. However, the dataset will be limited to students who enrolled in their first year of undergraduate studies and to courses taken only during their first semester, and these courses belong to the curriculum of that particular semester. This restriction is applied to prevent self-selection of students into classes, as will be discussed in detail in Chapter section 3.

To construct the final database, three distinct datasets are merged and organized: one containing student information, another with teacher characteristics, and a third encompassing class information. Initially, the student database includes details such as gender, date of birth, nationality, high school, PSU scores, NEM scores, cohort, municipality of residence and type of university admission. Throughout the data cleaning process, emphasis was placed on ensuring the recording of gender for all students, as it stands out as an essential variable in the study. Additionally, students lacking an identifier (constituting less than 0.001% of the sample) were excluded. Nationality information was further consolidated, categorized primarily as either *Chilean* or *Foreign*, given that over 90% of the students fall within the Chilean category. University admission types were dichotomized into two groups: *Regular* admission based on PSU scores and *Others*, encompassing various admission types like changes of career, children of university employees, foreigners, athletes, and others.

For simplicity, the student's municipality of residence was grouped into four categories: *Las Condes*, *Lo Barnechea*, *Vitacura* and *Others*, as the former three were the municipalities with the highest representation in the sample. Likewise, the type of school financing was classified into three categories: *Private*, *Public* and *Voucher*.

The second database corresponds to the teachers' database, which includes details such as gender, date of birth, nationality, educational level, and type of contract. Similar to the student database, teachers lacking an identifier (less than 1% of the sample) were excluded, and nationality was consolidated into *Chilean* and *Foreign*. Concerning the educational level of teachers, this variable was categorized into three groups. The first comprises individuals without a degree or diploma, higher-level technicians and bachelor degree holders, all falling under the category *Professional*. The subsequent two categories correspond to teachers with *Masters* and *Doctoral* degree. Finally, the teacher's employment contract was categorized to *Full Time Contract* and *Part Time Contract*.

Concerning the age of both students and teachers, it is computed based on the reference semester and year of the class. For instance, if a student is born in September 2000 and the course is scheduled for the first semester of 2020, the student's age at that time is 19.9 years. However, if the student was born in April, their age at that time would be 20.1 years.

The third database refers to classes, including information on both teacher and student identifiers, along with characteristics specific to each class: students' final grades, an indicator of course pass/fail, and the semester-year in which the class was conducted. Beyond these variables in the database, additional class characteristics were determined, such class size and the proportion of female students per class.

For this database, courses are classified into three groups: gender-balanced, female-dominated, and male-dominated. The gender-balanced category corresponds to courses offered by careers that consistently maintain a similar percentage of both men and women. Examples of such careers include Philosophy, Law, Communication, and Business. Female-dominated and male-dominated categories refer to courses where more than 70% of the students are women and men, respectively. Female-dominated programs include Nursing, Pedagogy, and Odontology, while male-dominated programs correspond to STEM careers. Appendix A provides the list of careers per gender category.

2.2 Descriptive Statistics

The dataset comprises a total of 74,668 records, covering 11,666 distinct students, 757 teachers, and 3,152 classes. Summary statistics for the database are provided in Table 1 by gender category.

In terms of student performance, considering the Chilean grading system from 1.0 to 7.0 with pass threshold of 4.0, male-dominated careers exhibit the lowest grade point averages (4.8) and approval rates (81%), while female-dominated careers demonstrate the highest grades (5.6) and approval rates (96%). Additionally, it is observed that female-dominated careers show the lowest standard deviation in approval rates and grades compared to other gender categories, indicating less variability in the probability of passing the course and grades.

On average, male-dominated careers feature a 27.7% representation of female teachers, followed by gender-balanced careers with 41.8%, and female-dominated careers with 68.7%. Consistent with the proportion of female students, female teachers are more prevalent in careers with higher female representation and less so in those dominated by males.

Table 1: Descriptive Statistics by Gender Composition

	Male-Dominated		Female-Dominated		Gender-Balanced	
	Mean	SD	Mean	SD	Mean	SD
Classes and teachers						
Grade	4.844	0.892	5.626	0.722	5.043	0.804
Pass/Fail	0.809	0.229	0.960	0.085	0.892	0.167
Female Teacher	0.277	0.448	0.687	0.464	0.418	0.494
Female Percentage	0.205	0.079	0.886	0.172	0.495	0.159
Class size	51.798	12.792	34.187	21.087	41.912	23.970
Teacher Age	40.560	13.146	47.689	11.001	46.357	11.207
Teacher Educational Level						
Professional	0.348	0.477	0.339	0.474	0.207	0.405
Masters	0.311	0.464	0.484	0.500	0.406	0.491
Doctoral	0.341	0.475	0.177	0.382	0.388	0.487
Chilean Teacher	0.901	0.299	0.954	0.209	0.934	0.249
Full Time Contract	0.227	0.420	0.418	0.493	0.431	0.495
Students						
Female Student	0.206	0.404	0.902	0.298	0.506	0.500
Student Age	18.948	1.165	19.897	4.122	19.028	1.330
Chilean Student	0.971	0.169	0.980	0.138	0.974	0.160
School Type						
Private	0.839	0.368	0.823	0.381	0.865	0.341
Public	0.058	0.234	0.050	0.218	0.039	0.193
Voucher	0.103	0.304	0.127	0.333	0.096	0.295
PSU Average	662.351	42.532	632.232	48.323	658.163	64.003
NEM	664.419	63.204	660.743	71.062	662.774	83.779
Standard Admission	0.812	0.391	0.787	0.410	0.844	0.363
Municipality						
Las Condes	0.332	0.471	0.261	0.439	0.287	0.452
Lo Barnechea	0.185	0.389	0.169	0.375	0.216	0.412
Vitacura	0.095	0.294	0.093	0.290	0.099	0.299
Other	0.388	0.487	0.477	0.500	0.398	0.490

Notes: Notes: SD corresponds to Standard Deviation. The dataset comprises information about the gender category male-dominated, female-dominated, and gender-balanced. These categories include 1,993; 4,541, and 5,012 students respectively; 101; 245 and 267 teachers respectively; and 267; 1,167 and 1,122 classes respectively.

Regarding class characteristics, the variable *female percentage* refers to the proportion of female students per class. Male-dominated careers show the lowest average female percentage at 20.5%, while female-dominated careers, as anticipated, demonstrate the highest at 88.6%. Gender-balanced careers typically maintain an equal distribution of male and female students. Additionally, male-dominated careers tend to have larger class sizes (52), followed by gender-balanced (42) and then female-dominated careers (34).

The youngest teachers, averaging 41 years old, are found in male-dominated careers, while the oldest teachers, averaging 48 years old, are in female-dominated careers. Gender-balanced and male-dominated careers have the highest number of teachers with Ph.D.s, whereas female-dominated careers have the highest percentage of teachers with Master's degrees. Regarding contract type, male-dominated careers predominantly feature part-time contracts, while female-dominated and balanced careers have a more even distribution, with an average of 42% on full-time contracts.

Regarding student characteristics, male-dominated careers enroll an average of 21% female students, gender-balanced careers enroll 51% female students, and female-dominated careers enroll 90% female students. These figures correspond to the definitions previously outlined for each gender category. When examining the PSU scores across the three categories, it is notable that there is no significant difference, as they average around 650 points. Similarly, the NEM scores also remain consistent, averaging around 660 points across all three categories.

Since the dataset exclusively comprises first-semester courses, the average student age approximates 19 years across all three categories. This aligns with the typical age at which students complete high school and begin university studies, assuming immediate enrollment.

The university predominantly enrolls students from private schools, with over 80% of its student population originating from such institutions. Approximately 10% come from voucher schools, while around 5% have an educational background from public schools. This pattern suggests that the university primarily attracts students from higher socio-economic strata. This trend is reinforced when analyzing the students' municipalities of origin, as the majority come from the eastern sector of Santiago (Vitacura, Las Condes, Lo Barnechea), recognized for its elevated income levels. Meanwhile, the percentage of students from other municipalities is considerably lower.

To reinforce the findings from the descriptive statistics, Figure 1 illustrates the evolution in the proportion of female teachers from 2012 to 2022. It is evident that female-dominated careers consistently maintain the highest percentage of female professors. Conversely, male-dominated careers exhibit a rising trend since 2013, gradually surpassing gender-balanced careers from 2018 onwards.

Figure 1: Percentage of Female Teachers by Gender Category Over Time

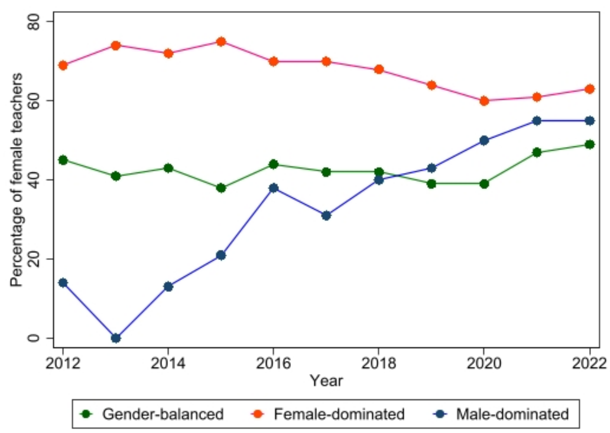
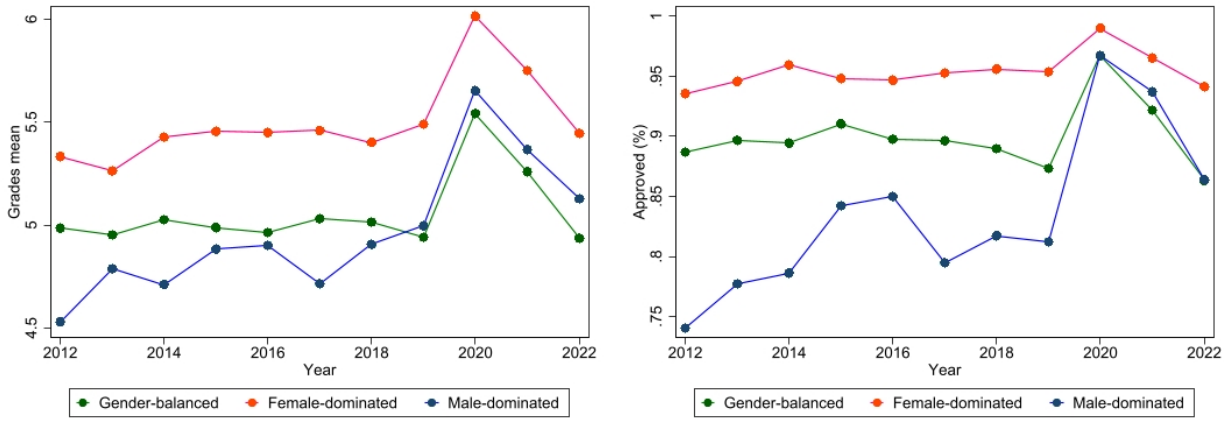


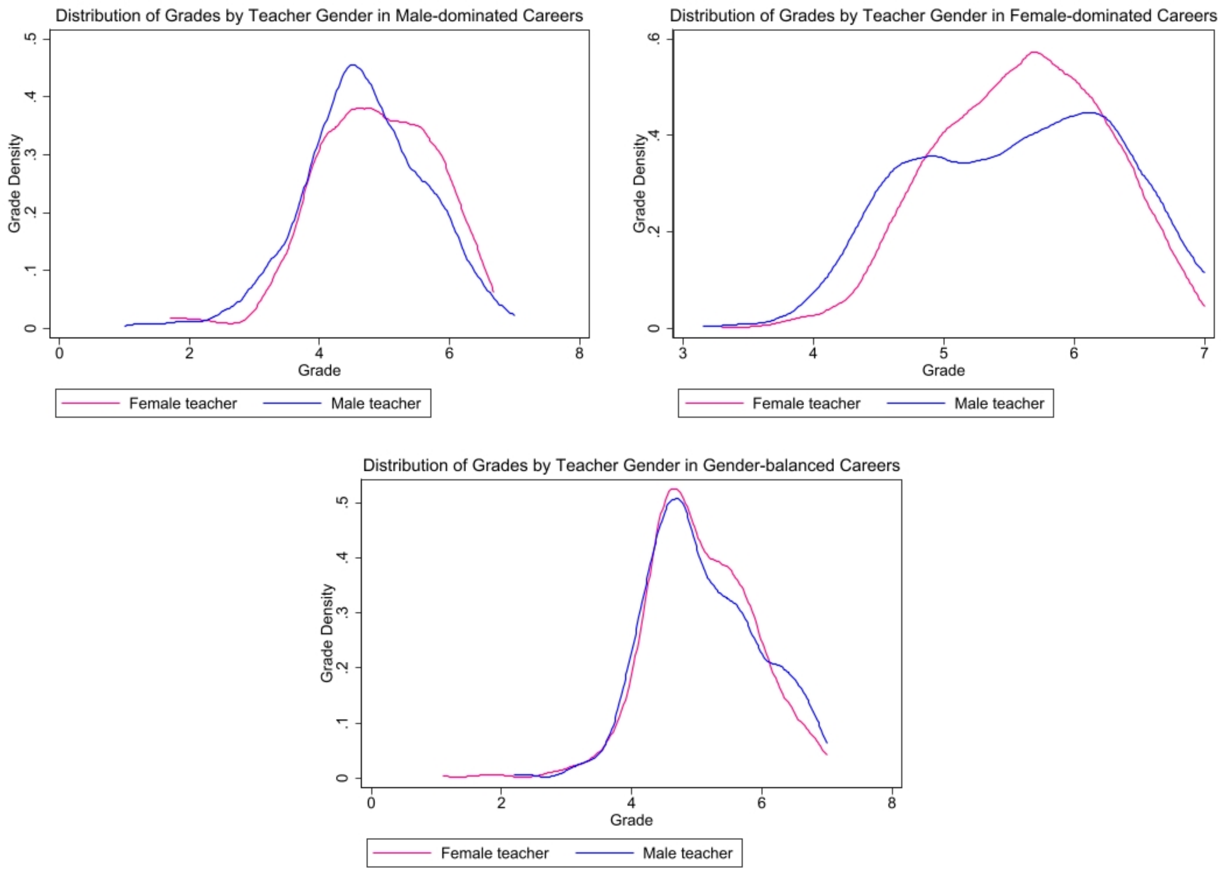
Figure 2 illustrates the evolution of grades and approval rates for each gender category over time, in the left and right panels respectively. In these figures, it is evident that the highest performance is observed in female-dominated careers, while the lowest grades are associated with male-dominated careers. Additionally, the figures highlight the impact of the pandemic and the shift to online classes, which notably increased grades and approval rates in 2020.

Figure 2: Grades and % Approved by Gender Category



In turn, Figure 3 illustrates the grade distribution based on the teacher gender across gender category. It is observed that in male-dominated careers (top left panel), classes taught by female professors tend to yield better student performance compared to those taught by male professors. On average, classes taught by female professors achieve a grade of 5.06, while those taught by male professors achieve a grade of 4.88, with a difference of 0.18 points (significant at 1%). Furthermore, in female-dominated careers (top right panel), female professors achieve slightly higher grades compared to male professors, with an average grade of 5.54 compared to 5.41, respectively, with a difference of 0.13 points (significant at 1%). Lastly, in gender-balanced careers, there is a similar grade distribution between male and female professors, with an average grade of 5.07 and 5.04 respectively, with a difference of 0.03 points (significant at 5%).

Figure 3: Students Grades by Gender Category and Gender Teacher



Finally, the consistently high percentage of female professors in female-dominated careers coincides with the superior academic performance observed in these fields, as evidenced by the higher grades reported in Figure 2 and the greater average grade attained in courses taught by female professors. Moreover, the increasing presence of female professors in male-dominated careers, highlighted in Figure 1, could be correlated to the tendency for students' performance to improve when taught by female professors in these fields, as indicated by the higher mean grades in Figure 3. These interrelations underscore the potential influence of teacher gender on student outcomes across various academic disciplines and highlight the importance of considering gender dynamics in educational settings.

3 Methods

This section studies the econometric models used to determine whether there is a causal effect on student performance based on the gender of the teacher. The identification strategy is discussed and empirical evidence is presented to support it.

3.1 Econometric Methods

As explained in section 2, the dataset used is for repeated cross-sectional, meaning that it is collected by observing many students, at a single point of time, specifically their performance in different classes. So, the notation used will be for each student i, in class k with teacher j.

To identify the effect of teacher-student gender matching, the base model is:

$$Y_{ijk} = \beta_0 + \beta_1 FS_i + \beta_2 FT_j + \beta_3 FT_j \times FS_i + \vec{\gamma} X_i + \vec{\delta} Z_{jk} + u_{ijk} \tag{1}$$

Outcome variables Y_{ijk} are: (i) the standardized final grade of the student in each class, and (ii) a binary variable indicating whether the student passed their class (1 for pass, 0 for fail). The grades were standardized by gender category, to facilitate comparison across careers of the same gender type.

In Equation 1, FS_i is the indicator of whether the student i is female; FT_j is the indicator of whether teacher j is female. The most important variable is the teacher's gender and its interaction with the student's gender, represented by $FT_j \times FS_i$. In the equation β_2 captures the value added of having a female teacher in comparison to a male teacher for male students, and $\beta_2 + \beta_3$ captures the value added of having a female teacher when the student is female. This allows to investigate whether the impact of teacher gender on student performance varies based on the gender of the student.

Also, control variables are included to check for the robustness of results. X_i is a vector of variables that includes student characteristics such as: age, nationality, funding school's type, cohort, PSU average score, NEM score, municipality of residence and type of admission; and Z_{jk} is a vector of variables that includes teacher and class characteristics. Teacher characteristics include: age, educational level, nationality and the type of contract, while class characteristics include: class size and female percentage.

Therefore, the change in the grade with respect to the teacher's gender is critical to quantify the causal effect. This is expressed as:

$$E(Y_{ijk}|FT_j = 1, FS_i, X_i, Z_{jk}) - E(Y_{ijk}|FT_j = 0, FS_i, X_i, Z_{jk}) = \beta_2 + \beta_3 FS_i$$

When FS_i is considered as 1 for female students, the change simplifies to $\beta_2 + \beta_3$, whereas when it takes the value of 0 for male students, the change reduces to β_2. Therefore, the key parameters are β_2 and β_3, essential for comprehending how the gender of the teacher influences student performance, distinguishing between male and female students.

In addition to including control variables, a model that accounts for student fixed effects is also estimated. The fixed effects regression method is used in data analysis to account for omitted variables that vary between different students but remain constant within classes for a given student. On average, each student is observed in six classes per semester. Authors such as Dee (2007), Holmlund and Sund (2008), Lim and Meer (2017) and Sansone (2019) use fixed effects per student to estimate causal effects.

Therefore, when accounting for both observable and unobservable characteristics with fixed effects for students across classes, the error term in Equation 1 (u_{ijk}) now splits into two parts. One part encompasses the individual error of students (ω_i), while the other part represents the idiosyncratic term (ϵ_{ijk}).

$$u_{ijk} = \epsilon_{ijk} + \omega_i$$

The model that includes student fixed effects is given by:

$$Y_{ijk} = \omega_i + \beta_2 FT_j + \beta_3 FT_j \times FS_i + \vec{\delta} Z_{jk} + \epsilon_{ijk} \tag{2}$$

Equation 2 includes ω_i as the fixed effect per student i. By including these fixed effects, variables like student age or gender, which remain constant for each student across different classes, are implicitly accounted for, leading to the exclusion of $\vec{\gamma} X_i$ from the original model due to perfect collinearity.

3.2 Causal Identification

To establish a causal relationship between teacher gender and student performance, ensuring independence between the treatment variable (FT_j) and model errors (u_{ijk}, ϵ_{ijk}) is imperative. This condition guarantees that any observed effect on the outcome of interest remains authentic and is not confounded with other factors. To achieve independence, two strategies have been implemented.

first, it is necessary to address the potential issue of self-selection of students to teachers that arises as students progress in their academic career and gain autonomy in selecting courses, teachers, and schedules. Self-selection has the potential to impact the association between teacher gender and student outcomes, thereby compromising the causal interpretation of the findings. In response to this concern, the analysis has been restricted to include only students in their inaugural year and semester of university.

During this initial stage of their academic trajectory, students lack autonomy in choosing their professors, classes or schedules, as these are automatically assigned by the educational institution. This automatic assignment in the initial semester/year eliminates the possibility of students' individual preferences, regarding the gender of the professor, influence the treatment received. Furthermore, in cases where there are multiple classes of the same course, the assignment of students to each class is randomized, which further mitigates the likelihood of self-selection. Moreover, the database includes only students whose year of entry into their career matches their year of entry into the university. This ensures that, in this context, the teacher's gender can be assumed to be exogenous.

Hence, the initial strategy to ensure independence between teacher gender and model errors involves restricting the sample to first-year/first-semester students, making sure that the database contains only the courses corresponding to the curriculum of that semester, thereby guaranteeing the exogeneity of teacher gender.

The second strategy entails integrating student fixed effects into the model. These fixed effects rigorously account for individual student characteristics that remain constant across classes and that could potentially impact both the treatment and observed outcomes.

By partitioning the model error into individual constant and idiosyncratic components through the inclusion of fixed effects, a substantial reduction in unexplained variability in the model is achieved. This approach bolsters the plausibility that teacher gender is exogenous.

Finally, the identification assumption in this causal analysis posits that, conditional on student fixed effects and the utilized control variables, teacher gender is independent of the idiosyncratic error.

3.3 Strategy Validation

Validation of the assumption of independence between teacher gender and model error is a fundamental step in supporting the robustness of causal analyses. Although this assumption is not directly testable, empirical evidence can be obtained using appropriate methods of analysis.

For this, a check is carried out to ensure that the teacher's gender is not correlated with observed variables that may influence the results. Following the methodology proposed by authors such as Paredes (2014) and Carrell et al. (2010), an empirical analysis is conducted through OLS regressions, where the dependent variable teacher gender (FT_j) is regressed on student characteristics, such as age, gender and academic history, among others. The objective is to determine if there is any significant correlation between the treatment factor and these student characteristics.

If the simple regressions show that the teacher gender is not significantly correlated with observed student characteristics, then it might be argued that teacher gender could also be independent of the idiosyncratic error term (ϵ_{ijk}) in the causal model.

Table 2 presents the regression results for student's characteristics in male-dominated careers. As can be observed, variables such as age, admission, nationality, and the type of school attended by the student do not exhibit significant correlation with teacher gender. While coefficients of characteristics such as average PSU scores, NEM scores, and the student's residential municipality are significant, it is apparent that these do not reflect a substantial economic difference between having a male or female teacher. For instance, for the average PSU score, the difference is 4.974 points; however, since the PSU is a test with a minimum score of 150 and a maximum of 850, a difference of 4.974 is inconsequential. The same argument applies for NEM scores and municipality, where less than 5 point and less than 10 pp, respectively can be considered rather small.

The respective tables for female-dominated and gender-balanced careers can be found in Appendix B, where similarly, no significant findings suggest a null correlation between teacher gender and observed student characteristics.

Consequently, by not finding significant associations between the teacher gender and student characteristics, confidence in the validity of the independence assumption between the teacher gender and the idiosyncratic error term (ϵ_{ijk}) is increased, reinforcing the robustness of the causal analyses conducted in the study.

Table 2: Balancing Test Masculinized Careers

	Coefficient	Std. err.
PSU Average	-4.974**	2.178
NEM	9.216**	3.916
Student Age	-0.069	0.470
Standard Admission	0.022	0.029
Chilean Student	-0.002	0.009
School Type		
Private	-0.014	0.011
Public	0.005	0.006
Voucher	0.009	0.008
Municipality		
Las Condes	0.038**	0.019
Lo Barnechea	-0.034*	0.017
Vitacura	-0.015	0.014
Other	0.011	0.009

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. A regression is estimated for each student characteristic. The dependent variable is teacher gender and independent variable is each characteristic of students. Standard errors are clustered by class.

4 Results

In this chapter, the main results of the estimated models by gender category are presented. These findings reveal the influence of teacher gender on student academic performance, measured in two ways: final course grade and approval rate. In addition, heterogeneity analysis is conducted to better understand if these effects vary according to class and/or teacher characteristics.

4.1 Main Results

Tables 3, 4, and 5 provide the estimated results of Equation 1, separately analyzing both grades and approval rate in male-dominated, female-dominated, and gender-balanced career fields, respectively. In columns (1) and (5), the regression model considers student performance solely in relation to the variables of interest: Female Teacher (FT_j), Female Student (FS_i), and their interaction ($FT_j \times FS_i$). Columns (2) and (6) include controls for student characteristics. Transitioning to columns (3) and (7), teacher and class characteristics are incorporated alongside student traits. Finally, columns (4) and (8) account for teacher and class control variables, and include student fixed effects as specified in Equation 2. Linear probability models are estimated for the pass/fail outcome. Additionally, clustering of errors was performed at the class level, accounting for any correlation in outcomes for students in the same class as done by Gong et al. (2018) and Hoffmann and Oreopoulos (2009).

As discussed in section 3, it is essential to examine the marginal effect of teacher gender on student performance, taking into account whether the students are male or female. Consequently, if the interaction is significant, the effect for female students corresponds to the sum of the teacher gender coefficient and the interaction term. Otherwise, if the interaction is not significant, male and female students experience the same effect given by the teacher gender coefficient.

Table 3 presents the results regarding the effect in male-dominated careers. Concerning the effect on grades when male students have a female teacher in comparison to a male teacher, it is observed that as we incorporate student, teacher, and class control variables, the coefficient remains around 0.127 standard deviations (sd). In particular, with the inclusion of student fixed effects, this effect becomes significant at 10%, indicating that male students increase, on average, their grades by 0.185 sd, which is equivalent to 0.217 grade points (gp) in the Chilean scale of 1.0 - 7.0.

Table 3: Main Results for Male-Dominated Careers

	Grade				Approved			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female Teacher (FT)	0.127	0.014	0.136	0.185*	0.051*	0.017	0.033	0.047
	(0.100)	(0.097)	(0.095)	(0.103)	(0.027)	(0.026)	(0.027)	(0.030)
Female Student (FS)	0.165***	0.041	0.032	-	0.042***	0.003	-0.000	-
	(0.034)	(0.031)	(0.026)	-	(0.012)	(0.012)	(0.012)	-
FT × FS	0.088*	0.100**	0.106**	0.102**	-0.000	0.006	0.008	-0.007
	(0.053)	(0.048)	(0.046)	(0.050)	(0.018)	(0.019)	(0.019)	(0.019)
Student Characteristics	No	Yes	Yes	No	No	Yes	Yes	No
Teacher/Class Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Student Fixed Effects	No	No	No	Yes	No	No	No	Yes
Observations	10,691	9,299	9,276	10,620	10,691	9,299	9,276	10,620

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

It is imperative to conduct a thorough analysis of the significance of the interaction term. In this context, the interaction consistently exhibits statistical significance, underscoring a notable distinction in the effects observed for male and female students. As a result, the effect observed for female students can be elucidated by summing the coefficients.

Also, Table 3 reveals that female students derive significant benefits from having a female teacher in all four models, showing a positive and significant coefficient. Upon examining column (4), it can be deduced that, on average, the benefit amounts to 0.286 sd, which corresponds to (0.185 + 0.102), significant at the 5% significance level. This translates to an equivalent of 0.336 gp. Furthermore, the analysis indicates no discernible effect of teacher gender on the approval probability for both genders as the coefficient are statistically non-significant.

Table 4 presents the results regarding the effect in female-dominated careers. When the student is male, it is observed that adding student control variables increases the effect fourfold. However, as teacher and course control variables are introduced, the effect begins to diminish and becomes statistically insignificant. Therefore, it can be concluded that there is no discernible effect on male students when taught by a female teacher in comparison to a male teacher.

Regarding the interaction, it is observed that when including teacher and class characteristics and then student fixed effects, it becomes positive and significant. Furthermore, for female students with a female teacher, controlling for these variables and fixed effects results in a positive and significant benefit of 0.112 sd on average, equivalent to 0.106 gp at the 5% significance level. Table 4 also shows small results with respect to approval probability with female teachers. For male students, there is no significant effect related to the teacher's gender. However, for female students, there is an effect of 0.033 at the 1% level when the teacher is female, indicating that female students have a 3.3% higher probability of passing when taught by a female teacher, which is considered rather small.

Table 4: Main Results for Female-Dominated Careers

	Grade				Approved			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female Teacher (FT)	0.067	0.252***	0.031	-0.001	0.003	0.018	0.008	0.013
	(0.079)	(0.080)	(0.069)	(0.062)	(0.012)	(0.014)	(0.014)	(0.011)
Female Student (FS)	0.177***	0.285***	0.121***	-	0.012	0.018*	0.011	-
	(0.049)	(0.045)	(0.034)	-	(0.009)	(0.010)	(0.010)	-
FT × FS	0.068	0.060	0.107*	0.113**	0.022*	0.025*	0.025*	0.020*
	(0.064)	(0.063)	(0.056)	(0.053)	(0.012)	(0.014)	(0.014)	(0.012)
Student Characteristics	No	Yes	Yes	No	No	Yes	Yes	No
Teacher/Class Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Student Fixed Effects	No	No	No	Yes	No	No	No	Yes
Observations	28,692	23,539	23,507	28,653	28,737	23,583	23,551	28,698

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

Lastly, Table 5 presents the main results for gender-balanced careers. It can be observed that, as control variables are incorporated, the effect does not change drastically. For male students, the effect is negative but small and almost insignificant. Additionally, as control variables are included, the interaction becomes positive and significant at the 1% significance level, requiring an analysis of the sum for both coefficients, for female students, the effect is very close to zero. Therefore, it can be concluded that there is no discernible effect for male or female students of having a female teacher in comparison to a male teacher.

For approval rate, it is also observed that there is no significant effect of having a female teacher. first, male students do not experience any effect. Then, the interaction remains significant at 0.02 at the 1% level; however, the effect for female students in model 4 (-0.009 + 0.025) is 0.015 at the 5% level, corresponding to a 1.5% higher probability of passing the class when the student is female and taught by a female teacher.

Table 5: Main Results for Gender-Balanced Careers

	Grade				Approved			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female Teacher (FT)	-0.059	0.005	-0.063	-0.065*	-0.008	0.001	-0.009	-0.009
	(0.051)	(0.044)	(0.039)	(0.037)	(0.011)	(0.010)	(0.010)	(0.010)
Female Student (FS)	0.321***	0.202***	0.069***	-	0.050***	0.024***	0.010*	-
	(0.019)	(0.019)	(0.015)	-	(0.005)	(0.005)	(0.005)	-
FT × FS	0.038	0.079***	0.085***	0.064***	0.021**	0.024***	0.024***	0.025***
	(0.028)	(0.027)	(0.025)	(0.023)	(0.008)	(0.009)	(0.009)	(0.008)
Student Characteristics	No	Yes	Yes	No	No	Yes	Yes	No
Teacher/Class Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Student Fixed Effects	No	No	No	Yes	No	No	No	Yes
Observations	28,712	25,306	25,306	28,668	28,712	25,306	25,306	28,668

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

4.2 Heterogeneity by Class Characteristics

It is important to conduct a heterogeneity analysis to gain a deeper understanding of the interplay among variables in the regression model. This type of analysis enables the examination of whether the effect of teacher gender varies among different subgroups within the sample.

The results are scrutinized for each gender category, and comparisons are drawn between the findings obtained from the entire dataset in section 5.1, where student fixed effects are used, and those observed when the dataset is divided into subsets. These subsets are delineated based on student grades within class, specifically divided into first (1^{st}), second (2^{nd}), and third (3^{rd}) terciles, as well as categorized by the median percentage of female representation and class size.

To analyze the effects according to the terciles of students' academic performance, each student is ranked within their class and classified into one of the three corresponding terciles. To evaluate heterogeneity based on the percentage of women in the class, regressions are conducted by separating students into those belonging to classes with a percentage of women above or below the median. Finally, to examine heterogeneity based on class size, the median of this variable within each gender category is calculated, separating between classes above and below the median.

Table 6 presents the results for heterogeneity in male-dominated careers. In these fields, grades are distributed as follows: the 1^{st} tercile shows an average grade of 4.22, the 2^{nd} tercile of 4.97, and 3^{rd} tercile of 5.60. In addition to academic performance, the analysis considers the median percentage of female students and class size within these male-dominated careers. The median percentage of female students in these classes is approximately 21%, indicating that women are significantly under-represented in these fields. Moreover, the median class size in male-dominated careers is around 56 students.

The analysis reveals several notable findings regarding the influence of having a female teacher. firstly, when examining the terciles of student performance, it is observed that students in the 3^{rd} tercile experience significant benefits from having a female teacher. This positive effect of 0.181 sd (at 5% significance) equivalent to 0.212 gp for both male and female students, suggest that high-performing students gain more from female instructors regardless of their own gender.

Secondly, in classes where the percentage of female students exceeds 21%, the presence of a female teacher also leads to improved student outcomes, although the interaction is not significant, so that for both male and female students the effect is 0.309 sd at 5% significance, which is equivalent to 0.363 gp. This indicates that a higher representation of female students in a class amplifies the positive impact of female teachers, potentially due to a more supportive and relatable classroom environment. Lastly, the analysis considers the effect of class size. It is found that larger classes generally have a positive effect on student performance for both male and female students when taught by a female teacher in comparison to a male teacher. However, the magnitude of this benefit differs between genders. Female students benefit significantly more, with an increase of 0.525 sd equivalent to 0.616 gp, compared to a 0.415 sd equivalent to 0.487 gp improvement for male students. This suggests that female teachers are particularly more effective than male teachers in managing and delivering quality education in larger classes, especially for female students.

Table 6: Heterogeneity of Classes Characteristics on Male-Dominated Career Grades

		Terciles			Female Percentage		Class size	
	Full Sample	1^{st}	2^{nd}	3^{rd}	< 0.21	≥ 0.21	< 56	≥ 56
Female Teacher	0.185*	0.156	0.143	0.181**	0.031	0.309**	0.045	0.415**
	(0.103)	(0.125)	(0.106)	(0.090)	(0.167)	(0.144)	(0.147)	(0.163)
FT × FS	0.102**	-0.058	0.147	0.091	0.049	0.064	0.084	0.110*
	(0.050)	(0.109)	(0.108)	(0.067)	(0.087)	(0.053)	(0.068)	(0.064)
Student Characteristics	No	No	No	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,620	3,656	2,899	2,522	5,005	5,081	5,001	5,106

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

Table 7 presents the results for heterogeneity in female-dominated careers. The average grades for students are 4.81 in the 1^{st} tercile, 5.54 in the 2^{nd} tercile, and 6.15 in the 3^{rd} tercile. It is observed that female students in the 2^{nd} tercile benefit the most from having a female teacher, with a significant effect of 0.137 sd at the 10% significance level, which is equivalent to 0.130 gp. Additionally, both male and female students in the 3^{rd} tercile experience a positive and significant effect of 0.122 sd from having a female teacher, which is equivalent a 0.116 gp. Concerning the first tercile, although the interaction is significant, the effect for female students is 0.106 sd with a p-value of 0.109, implying no effect.

Regarding the percentage of female students in the class, where the median corresponds to 94%, aligning with the average percentage of women in this category, it is observed that female students benefit from having female teachers, with an increase in performance of 0.184 sd. However, upon further subgroup analysis, the sample size decreases, consequently increasing the margin of error, thereby rendering the effect statistically non-significant. Lastly, concerning class size, no effect of having a female teacher for male students is observed in any case. However, in classes below the median size, comprising fewer than 45 students, female students benefit from having a female teacher, exhibiting an average effect of 0.138 sd with a significance level of 10%, equivalent to 0.131 gp.

Table 7: Heterogeneity of Classes Characteristics on Female-Dominated Career Grades

		Terciles			Female Percentage		Class size	
	Full Sample	1^{st}	2^{nd}	3^{rd}	< 0.94	≥ 0.94	< 45	≥ 45
Female Teacher	-0.001	-0.051	0.006	0.122*	-0.021	0.008	-0.083	-0.147
	(0.062)	(0.085)	(0.081)	(0.064)	(0.072)	(0.133)	(0.087)	(0.093)
FT × FS	0.113**	0.157*	0.131*	-0.075	0.049	0.175	0.221**	0.105
	(0.053)	(0.081)	(0.075)	(0.062)	(0.045)	(0.113)	(0.089)	(0.076)
Student Characteristics	No	No	No	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,653	10,374	8,428	6,855	13,904	13,863	12,530	14,275

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

Lastly, Table 8 presents the results for grades in gender-balanced careers. The average grades for students are 4.40 in the 1^{st} tercile, 5.18 in the 2^{nd} tercile, and 5.78 in the 3^{rd} tercile. As expected, the median percentage of women corresponds to 50%, and finally, the median class size is 53 students.

In the results corresponding to the terciles, it is observed that for male students in the first tercile, there is a negative effect of having a female teacher, with a coefficient of -0.080 sd, equivalent to a decrease of 0.085 gp, at 10% significance. However, it could be argued that the effect is quite minimal. Additionally, the interaction for the first tercile is shown to be significant and even higher than when estimating the full sample, indicating a difference in performance between male and female students. Yet, when estimating the marginal effect for female students, there is no statistically significant effect (-0.005 sd with a p-value of 0.918).

Table 8: Heterogeneity of Classes Characteristics on Gender-Balanced Career Grades

		Terciles			Female Percentage		Class size	
	Full Sample	1^{st}	2^{nd}	3^{rd}	< 0.5	≥ 0.5	< 53	≥ 53
Female Teacher	-0.065*	-0.080*	-0.041	-0.002	-0.044	-0.084	-0.008	-0.059
	(0.037)	(0.048)	(0.038)	(0.031)	(0.052)	(0.053)	(0.050)	(0.058)
FT × FS	0.064***	0.075*	0.004	0.004	0.082***	0.055**	0.083***	0.062*
	(0.023)	(0.042)	(0.028)	(0.031)	(0.027)	(0.027)	(0.032)	(0.035)
Student Characteristics	No	No	No	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,668	9,952	8,338	7,015	13,306	14,735	13,753	13,215

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

The observed pattern recurs when examining the outcomes associated with the percentage of female students in the class and class size. In both cases, all interactions were significant and even larger than when estimating the full sample. However, there is no significant effect on female students. Specifically, concerning the percentage of females in the class, the effect on female students is 0.038 sd below the median and -0.029 as above the median, with corresponding p-values of 0.591 and 0.505, respectively. Similarly, for class size, the effect is 0.076 sd below the median and 0.003 sd above the median, with p-values of 0.150 and 0.955, respectively. Ultimately, no significant effect of having a female teacher on the terciles of grades, the percentage of females in the class, or class size is evident.

Finally, the analysis of the heterogeneity in the approval rate by class characteristics can be found in the Appendix C with similar results to those mentioned in grade.

4.3 Heterogeneity by Teacher Characteristics

In addition to the above analysis based on class characteristics, it is also important to examine if the observed effects vary by certain teacher characteristics. Specifically, the study focuses on determining whether the effect is attributed to younger or older female teachers, or if it is related to the possession of a doctoral degree. Therefore, in this section, an analysis is conducted to determine if the effect varies depending on whether the teacher is above or below the median age in each gender category, or holds a doctoral degree.

Table 9 presents the results for teacher heterogeneity in male-dominated careers. The findings reveal intriguing variations in the effect of having a female professor based on specific attributes.

Table 9: Heterogeneity of Teacher Characteristics on Male-Dominated Career Grades

		Teacher Age		Doctoral Degree	
	Full Sample	< 36	≥ 36	No	Yes
Female Teacher	0.185*	0.122	0.391***	0.327***	0.048
	(0.103)	(0.173)	(0.148)	(0.117)	(0.262)
FT × FS	0.102**	0.068	0.050	0.127**	-0.052
	(0.050)	(0.084)	(0.075)	(0.057)	(0.090)
Student Characteristics	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	10,620	5,069	5,115	6,739	3,061

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

It is observed that for both male and female students, the effect of having a female professor is 0.391 sd at the 1% significance level, equivalent to 0.459 gp, when she is above the median age of 36 years. This suggests a substantial positive influence on student performance attributable to older female professors within male-dominated career settings. Furthermore, the analysis reveals that both male and female students benefit when the female professor lacks a Ph.D., with the effect size being more pronounced for female students. Specifically, the effect size for female students is significantly higher at 0.453 sd, compared to 0.327 sd for male students, both significant at the 1% level, and equivalent to 0.531 gp and 0.384 gp respectively. This indicates that female students derive greater academic advantages from female professors without doctoral degrees within male-dominated career contexts, compared to their male counterparts.

Table 10 presents the results for heterogeneity in female-dominated careers, highlighting variations in the effect of female teachers based on certain characteristics.

For younger female teachers, those below the median age of 46, male students perform worse by an average of 0.220 sd equivalent to 0.209 gp, at a 5% significance level, while there is no significant effect observed for female students (0.038 sd and p-value of 0.652). Conversely, for female teachers above the median age, although the interaction is significant, there is no discernible effect on female students (0.121 sd p-value of 0.150). Furthermore, if a female teacher does not hold a Ph.D., female students benefit by 0.276 sd equivalent to 0.262 gp and male students by 0.130 sd equivalent to 0.124 gp on average, significant at the 1% and 10% level respectively. However, if the female teacher holds a Ph.D., the effect becomes negative and significant, with female students experiencing a decrease in grades of 0.521 sd and male students 0.675 sd on average, significance at the 1% level, which is equivalent to 0.495 gp and 0.641 gp respectively.

Table 10: Heterogeneity of Teacher Characteristics on Female-Dominated Career Grades

		Teacher Age		Doctoral Degree	
	Full Sample	< 46	≥ 46	No	Yes
Female Teacher	-0.001	-0.220**	-0.001	0.130*	-0.675***
	(0.062)	(0.093)	(0.094)	(0.075)	(0.115)
FT × FS	0.113**	0.258***	0.122*	0.146**	0.154**
	(0.053)	(0.075)	(0.073)	(0.061)	(0.072)
Student Characteristics	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	28,653	13,584	14,043	22,951	4,079

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

Table 11 presents the results for heterogeneity in gender-balanced careers. It is observed that female professors over the age of 46 have a impact on students. Specifically, male students exhibit a negative effect of 0.088 sd, equivalent to 0.094 gp at 10% significance, which is a minimal effect. Furthermore, while the interaction is significant and positive, the analysis shows that the result is not significant for female students (-0.088 + 0.079 = -0.009).

Additionally, an interesting finding emerges concerning the possession of a Ph.D. degree by female professors. Both male and female students experience a decline in their grades, with the effect being statistically significant at the 5% level. On average, students' grades decrease by 0.138 sd, or 0.147 gp, when taught by female professors with Ph.D. degrees. This indicates that the presence of female professors with Ph.D. degrees may have a negative impact on student performance in gender-balanced career contexts, irrespective of the students' gender.

Table 11: Heterogeneity of Teacher Characteristics on Gender-Balanced Career Grades

		Teacher Age		Doctoral Degree	
	Full Sample	< 46	≥ 46	No	Yes
Female Teacher	-0.065*	-0.081	-0.088*	-0.018	-0.138**
	(0.037)	(0.057)	(0.053)	(0.051)	(0.069)
FT × FS	0.064***	-0.005	0.079**	0.092***	-0.039
	(0.023)	(0.036)	(0.032)	(0.029)	(0.046)
Student Characteristics	No	No	No	No	No
Teacher/Class Characteristics	Yes	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	29,668	13,400	13,577	17,421	10,074

Notes: Clustered standard errors at class level presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Student level control variables include age, nationality, school type, PSU average, NEM scores, admission, and municipality. Teacher level control variables include age, educational level, nationality and contract. Classes level control variables include class size and female percentage.

Finally, the analysis of the heterogeneity in the approval rate by teacher characteristics can be found in the Appendix C, the approval rate conclusions do not change with respect to what was recently mentioned in grade.

5 Analysis and Discussion

In the previous section, the results of the effect of teacher gender were shown in three contexts: an environment perceived as hostile to women, characterized by male dominance among both students and teachers represented by STEM fields; the opposite scenario, examining the impact on students' academic performance in settings where women predominate among both faculty and students, such as in Education and Health; and a gender-balanced environment among teachers and students, such as in Law and Business. This chapter analyzes the finding and discusses the implications of the results observed in the previous section.

5.1 Male-dominated Careers

The influence of teacher gender on student performance within male-dominated careers is positive and statistically significant. Male students, on average, increase their grades by 0.185 sd when taught by a female teacher, at a 10% significance level, while female students see an increase of 0.286 sd at a 5% significance level. This suggests that the presence of a female teacher is associated with improved overall student performance in comparison with a male teacher, particularly benefiting female students.

According to the analysis of heterogeneity by class characteristics, both male and female students in the 3^{rd} tercile, those with higher academic performance, are the ones who benefit from having a female teacher. Their grades improve by an average of 0.181 sd at a 5% significance level. Another relevant factor in male-dominated careers is the proportion of female students in the class. When the proportion of female students in a class is above the median and they have a female teacher, both male and female students increase their grades by an average of 0.309 sd at a 5% significance level. Lastly, the effect is more pronounced in larger class sizes, with average increases of 0.415 and 0.525 sd for male and female students respectively, both at a 5% significance level.

As previously mentioned, women studying in traditionally male-dominated careers tend to obtain better grades. This trend suggests that an increase in the proportion of women in these careers could have a positive effect on student performance, as more female students may be motivated by the example and impact of having a female teacher as a role model, which in turn could contribute to an overall improvement in grades.

Our findings are in line with Carrell et al. (2010). They document a gender gap in various dimensions of STEM success, which diminishes significantly when female students are taught by female professors, though this effect is not observed in the humanities. The positive impact of female teachers is most pronounced among female students with strong math abilities, particularly those in the upper quartile of SAT math scores, which in this study refers to the 3^{rd} tercile. For these students, having a female teacher eliminates the gender gap in introductory course grades and increases enrollment in science majors. Conversely, teacher gender has minimal influence on male students' academic outcomes. Carrell et al. (2010) suggests that the pronounced effect among high-achieving students may be due to role modelling.

In turn, Paredes (2014) provides further support for this theory, suggesting that the substantial impact of female professors on female students in male-dominated fields aligns with the role model hypothesis. This effect appears particularly pronounced in students with fewer female teachers. However, her study also reveals no discernible effect to male students. This discrepancy with this study may be attributed to her study's focus on schools, as well as the consideration of mothers' educational levels.

Other similar results are from Gong et al. (2018), who suggest that female teachers significantly improve female students' test scores compared to male students. In their study, the absolute improvement for female students by having a female teacher is about 0.104 sd, whereas in this study it is 0.285 sd. The difference can be attribute to in their study is in schools and do not separate between gender category, they also include variables such as mother's education and socio-economic level.

Regarding the heterogeneity of teacher characteristics, it is observed that female teachers above the median age of 36 in engineering have a positive effect on student performance, with an average increase of 0.391 sd at the 1% significance level for both male and female students. Additionally, both genders benefit when their female teachers do not hold a doctoral degree. However, the improvement is even greater for female students, with an average increase of

0.454 sd for females and 0.327 sd for males.

In particular, it is believed that older female teachers demonstrate softer skills, such as empathy, organization, and understanding, in comparison to their male counterparts, which positively contribute to student performance. Conversely, the possession of a doctorate by female teachers may potentially diminish these soft skills, giving rise to two plausible theories. The first suggests that women pursuing doctoral degrees are less likely to have children earlier, as they devote their time to advancing their careers, potentially leading to a decline in these skills. The second theory posits that women in STEM fields seeking doctoral degrees face heightened pressure to excel in male-dominated environments, potentially resulting in more stringent teaching approaches and, consequently, students perform better with teachers who do not have a doctorate. However, these theories remain speculative, lacking empirical validation with current dataset available.

It is possible to assert that the low presence of female teachers in faculty of traditionally male-dominated fields accentuates the impact of their distinctive characteristics compared to their male colleagues. These characteristics are particularly evident in larger classes, where classroom management and reducing disruptions are more challenging. In contrast, smaller classes tend to have a more controlled and calm environment, facilitating effective teaching regardless of the instructor's gender, which may explain why the effect is particularly noticeable in large classes.

According the approval rate, the direction of the effect aligns with the findings discussed for grades. Consequently, the analysis is consistent with the previous discussion. Larger classes with a higher proportion of female students have a greater probability of passing when the teacher is a woman, particularly if the teacher is above the median age and does not hold a doctoral degree. However, change in the probability is small. Therefore, it can be concluded that there is very limited effect on the approval rate from having a female teacher in comparison to a male teacher.

5.2 Female-dominated Careers

The impact of the teacher's gender on student performance in female-dominated environments is positive and significant. Specifically, female students taught by female teachers experience a positive and significant effect of 0.112 sd at the 5% significance level. Conversely, for male students, the teacher's gender does not appear to influence their performance. This finding is initially surprising, as it might be expected that in a predominantly female environment, the gender of the teacher would not have a differential impact. This suggests that the interaction between teacher and student gender is important for the academic performance of female students, potentially due to factors such as the role model effect or the presence of teacher bias.

Nevertheless, the role model theory is discounted in this context, as female students do not seem to find a role model in an environment where they are already well represented. Instead, the teacher bias theory could explain these results, suggesting that female professors might teach female students more effectively and treat male students differently due to stereotypes. Given that men represent on average less than 10% of the enrollment in female-dominated fields, it is reasonable to think that female professors might not be accustomed to their presence and behave differently towards them.

Heterogeneity analysis reveals that female students in the 2^{nd} tercile of performance benefit the most from having a female teacher, with a positive effect of 0.137 sd significant at 1% significance level. In addition, both male and female students in the top performing tercile also benefit from having a female teacher of 0.122 sd at 10% significance level.

Analyzing the heterogeneity results, it is observed that female students in the middle tercile significantly benefit from having a female teacher, with an improvement of 0.137 sd in their grades. This finding suggests that female teachers may be providing additional support or adapting their teaching methods to help these students, who are striving to improve their grades to reach average levels. Female teachers may recognize the challenges these students face and focus on guiding them more effectively, perhaps using more empathetic and understanding pedagogical strategies.

Furthermore, it was found that both male and female students in the 3^{rd} tercile (those with the highest performance) also improve their grades equally, with an increase of 0.122 sd when they have a female teacher. This result could be related to the softer skills that female teachers possess in comparison with male-teachers, such as empathy, effective communication, and the ability to inspire and motivate their students. These skills can create a more positive and supportive learning environment, benefiting all students regardless of their gender, but especially those who are already high achievers.

It is important to consider that, in general, grades in female-dominated fields are high in comparison whit male-dominated grades, with an average of 5.54 in the 2^{nd} tercile and 6.15 in the 3^{rd} tercile. This context of generally high performance could make differences in the impact of teacher gender more noticeable among students at the extremes of academic performance, whether striving to reach the average or maintaining outstanding performance. Female teachers, being possibly more attuned to the emotional and academic needs of their students, may provide the type of support that fosters continuous improvement, especially in an environment where performance expectations are already high.

On the other hand, students in the 1^{st} tercile do not show a significant effect of having a female professor. One possible explanation for this lack of effect is that these students, having lower performance, might be facing deeper academic and personal challenges that cannot be overcome solely through the support and soft skills that female professors provide. These students may need more intensive and specific interventions to improve their performance, which are not captured by the mere presence of a female professor in the classroom. Additionally, these students may be less motivated or less receptive to the teaching style of female professors, thereby limiting the potential impact.

The proportion of women in the class does not show a significant difference in relation to having a female professor, indicating that the number of women in the class does not influence the positive impact of having a female professor. Although the result is not statistically significant, the positive coefficient of 0.175 sds suggests a favorable trend. Given that the median percentage of women in a course is 94%, this implies that the courses are predominantly composed of women, and suggests that in these female-dominated environments, female professors can further enhance the academic performance of female students due to the previously mentioned stereotypes.

Additionally, class size does not show a significant difference in this relationship, suggesting that the number of students does not affect the positive impact of having a female teacher.

Regarding teacher characteristics, it is observed that younger female teacher have a negative effect on male students, possibly due to the previously mentioned gender stereotypes. On the other hand, female teacher without a Ph.D. present a positive and significant effect for both genders: an increase of 0.130 sd at the 10% significance level for men and 0.276 sd at the 1% significance level for women. In contrast, female professors with a Ph.D. show a negative and significant effect, with a decrease of 0.675 sd for men and 0.521 sd for women, suggesting that students perform worse with more academically qualified female professors.

This negative effect is less pronounced for female students, which could be attributed to a role model effect. Although female teacher with Ph.D. may present a greater academic challenge, female students may feel inspired and motivated by the presence of a highly qualified female figure, partially mitigating the negative effect observed on performance.

Then, while the proportion of women in the course and class size do not significantly influence the impact of having a female professor, the specific characteristics of the female professors do. Younger female professors negatively affect male students, possibly because they replicate the behavior of their own female teachers, thereby normalizing stereotypes against men. Conversely, female teachers without a doctorate have a positive effect on both genders. Female professors with a doctorate, although generally having a negative effect, affect women less negatively due to a possible role model effect.

In contrast to this study, Bettinger and Long (2005) investigate the effect of male teachers on male students in under-represented fields. Their analysis aimed to determine whether having a male teacher in a female-dominated discipline positively impacted male students' interests. While no effect was found in most disciplines except business, significant effects were observed in education. Male students with male teachers in initial education courses enrolled in more subsequent credit hours and were more likely to major in the subject. These findings support the idea that same-gender faculty can positively influence student interest in a subject. The study recommends further research to explore the impact of faculty on student interests and performance.

In addition, the approval rate results show that having a female professor increases the probability of passing the class for students in the worst and middle performing tercile, which may be explained by the additional motivation provided by female professors as role models.

5.3 Gender-balanced Careers

Teacher gender does not have a significant effect on student performance. This suggests that in environments where both genders are equally represented among students and faculty, the influence of teacher gender is minimized, reflecting an ideal model for educational equity across all fields.

Upon further examination of heterogeneity, it becomes evident that the presence of a doctoral degree among female teachers correlates with a decrease in grades for both male and female students, averaging 0.138 sd with a significance level of 5%. This finding aligns with the theory observed across all gender categories, indicating that female professors with Ph.D.

may adopt stricter teaching approaches. However, in this context, there is no discernible effect of role model or bias, as the negative impact is consistent across both genders. This neutrality in impact suggests a balanced classroom dynamic in terms of gender representation among students and teachers.

In comparison to male-dominated fields, both male and female students benefit positively from female teachers in gender-balanced careers. This positive effect may be attributed in part to the scarcity of female faculty members, which accentuates their unique contributions and role model influence, particularly for female students, leading to enhanced academic performance relative to their male counterparts. However, in female-dominated fields, the significant positive impact of female teachers is primarily observed among female students. This discrepancy suggests a nuanced interplay of bias and role model, with female professors potentially favoring female students and serving as aspirational figures for girls. While the influence of teacher gender is more discernible in gender-balanced fields, its impact is predominantly observed among female students.

Furthermore, across all analyzed categories, it is noted that the presence of a Ph.D. among female professors generally negatively impacts students' grades. This trend may arise from the heightened expectations and academic rigor associated with female professors holding advanced degrees. Consequently, students may encounter greater academic challenges under their instruction, potentially leading to lower overall academic performance. Additionally, female professors with doctoral degrees often focus intensely on their academic research and scholarly pursuits. This strong emphasis on academic excellence and research can sometimes come at the expense of developing effective teaching skills and pedagogical techniques. As a result, these professors might not possess the same level of talent in educational methods as their counterparts without Ph.D.. The combination of rigorous academic standards and potentially less refined teaching strategies could further contribute to the observed decline in student grades.

Following the approach proposed by Paredes (2014), the inquiry revolves around whether the effect of female teachers on female students stems from role model or stereotype threat theory. According to the author, a stronger effect would be anticipated for girls in traditionally male-dominated subjects, such as mathematics, and a less pronounced effect in language subjects if the positive impact of female teachers on girls is attributed to teacher behavior. Conversely, if the effect is linked to teacher bias, a greater impact would be expected in mixed-gender classrooms. While Paredes (2014) does not segregate students by gender composition in her analysis, she draws a common conclusion regarding the role model theory, but does not find support for the stereotype threat theory.

Finally, fostering a gender-neutral academic environment is imperative for promoting diversity and equality in education. Striving for a balance between male and female representation among both teachers and students across all disciplines is crucial. Ideally, the influence of a teacher's gender on student performance should be minimized, ensuring that academic success is determined solely by merit and effort rather than gender dynamics. Despite existing research by authors like Zafar (2013), Gong et al. (2018) and Aguirre et al. (2020), indicating variations in career preferences between men and women, it is essential to acknowledge that these differences may be perpetuated by societal stereotypes and a lack of gender-diverse role models in certain fields. Addressing these stereotypes and increasing the visibility of diverse role models can pave the way for a more inclusive and supportive educational landscape, benefiting students and educators alike. Through concerted efforts to challenge biases and promote gender equality, it can create an environment where all individuals have equal opportunities to thrive and succeed in their academic pursuits.

6 Conclusions

Beginning with the historical and persistent issue of gender disparity in STEM fields, this paper sought to uncover the effect of teacher gender on high education students' academic performance. The gender wage gap remains a significant challenge worldwide, with women often earning less than their male counterparts despite similar qualifications and experience. Therefore, investigating differences in relation to the gender of the teacher could reveal that positive female role models inspire young women to follow in their footsteps and excel in higher-paying fields, such as those dominated by men, thus helping to reduce the wage gap.

Our main objective was to determined whether the gender of the teacher has a causal effect on the immediate academic performance of students in higher education, both males and females in three specific career contexts: male-dominated, female-dominated, and gender-balanced. Using data from *Universidad de los Andes* in Santiago, Chile over a 10-year period, we estimated both OLS and individual fixed effects regression. The study also includes heterogeneous effects about how the results vary according class and/or teacher characteristics.

To establish causality between teacher gender and student performance, two strategies are employed: analyzing only first-year students with randomized class assignments and incorporating student fixed effects to control for individual characteristics. An empirical analysis confirms that teacher gender does not significantly correlate with observed student characteristics, validating the independence assumption and reinforcing the robustness of the study's causal analyses.

The proposed econometric models and their heterogeneity analysis were examined across the three gender categories. In male-dominated careers, we found that the gender of the teacher positively influences student performance. Both male and female students significantly improve their grades when taught by female professors. In particular, students with higher academic achievement and those in classes with a proportion of females above the median experience greater improvements in their grades with female professors. In addition, in larger classes, a greater increase in student achievement is observed when the teacher is female. It is suggested that the presence of female professors in male-dominated careers may serve as a role model for female students, potentially motivating the latter and improving their academic performance. Older female professors and those without a Ph.D. are observed to have a more positive effect on student performance, possibly due to soft skills such as empathy, organization, and expertise. Our findings are consistent with previous research suggesting that the gender gap in academic achievement in STEM areas decreases when students are taught by female teachers.

Second, female-dominated careers demonstrate a positive and significant effect of teacher gender on student achievement. Specifically, female students taught by female teachers experienced a noticeable increase in their grades, whereas for male students teacher gender had no significant impact. Although it was expected that in a predominantly female environment the gender of the teacher would not have a differential impact, the results suggest otherwise. Initially, the role model theory is dismissed and it is suggested that gender biases could explain these results, as female teachers might teach female students and male students differently due to stereotypes.

It is observed that female students in the second tercile of academic achievement benefit the most from having a female teacher. In addition, both male and female students in the upper tercile also benefit from having a female teacher. Younger female teachers were found to have a negative effect on male students, while those without a Ph.D. had a positive effect on both genders, confirming stereotype theory especially in younger female professors. However, female professors with a Ph.D. show a negative effect, although this effect is less pronounced in female students due to a possible role model effect. Results are compared with previous research suggesting that the presence of same-gender professors can positively influence student interest and performance.

Lastly, in gender-balanced careers, no significant effect of teacher gender on student achievement was found in gender-balanced environments. This suggests that in environments where both genders are equally represented among students and teachers, the influence of teacher gender is minimized, reflecting an ideal model for educational equity in all domains.

In summary, in male-dominated fields, students' grades improve when taught by a female professor, with female students' grades improving twice as much. Conversely, in female-dominated fields with female professors, only the grades of female students show a significant improvement, though this is less than half the effect observed in female students in male-dominated fields. Finally, in gender-balanced fields, no significant effect is observed. Therefore, it is suggested that the best scenario is one in which there is a gender balance. Additionally, it is in these male-dominated environments, which can be particularly challenging for women, where female students benefit the most, perhaps due to the presence of a role model or increased support from female professors.

It is recommended for policymakers that when hiring university professors, they take into account the gender composition of the field. It has been demonstrated that male-dominated fields also tend to have a predominance of male professors, and the opposite is true for female-dominated fields. Therefore, universities should increase the number of female professors in male-dominated fields. The presence of women in teaching roles not only serves as role models for female students but can also improve the academic performance of all students. Increasing female representation in these areas can promote diversity, inclusion, and help reduce gender biases in academic performance. Other factors to consider include the age of female professors, as more experienced women benefit student outcomes, especially in large classes, for both male and female students.

Similarly, in fields dominated by women, it is advisable to increase the hiring of male professors. While the impact of teacher gender may be less pronounced in these fields, greater gender diversity among faculty members can contribute to a more balanced educational environment and help break down stereotypes. Across the three gender categories, it is important to highlight that, in general, students tend to improve their grades with professors who do not hold a Ph.D. and see a decline with those who do. Therefore, it should be considered whether the former are too lenient in their evaluations or if the latter take an especially strict approach when assessing students.

This study sheds light on the relationship between teacher gender and student performance in higher education, revealing its indirect impact on the gender wage gap. As students navigate their career paths, the influence of teacher gender on academic performance emerges as a pivotal factor. Understanding these dynamics is essential for crafting strategies to foster gender parity, narrow the wage gap, and ensure equitable opportunities for women in lucrative, male-dominated fields. By advocating for increased representation of female educators in traditionally male-dominated disciplines, universities can pave the way for bridging gender disparities in STEM fields. This shift promises not only enhanced prospects for female students but also challenges entrenched gender norms and biases. Consequently, as more women graduate on time and with distinctions, their likelihood of securing better-paying jobs in the future increases, contributing to a more equitable distribution of wealth and opportunities in society. Ultimately, fostering an educational environment where teacher gender does not constrain student potential emerges as a crucial step in combating the gender wage gap and advancing gender equality in the workforce.

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