Whether your name is Manuel or María matters: gender biases in recommendations to study engineering

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Abstract

We conducted a simple controlled experiment to detect gender biases (or double standards) that potential tutors may have when assessing the mathematical ability of teenagers or when advising them on their career choice. We presented a fictional profile of a 15-year-old person (called Manuel or María, with two possible levels of academic record, intermediate or high) to the participants in our study (university students from Spain and Colombia) and asked them to evaluate his/her mathematical ability and advise him/her about whether or not to study engineering in the future. We considered the perception of the target's mathematical ability as a variable mediating in the effect of the target's gender on the recommendation to study engineering. Additionally we considered some moderating variables such as the participants' country of residence, gender and field of study. Our results suggest that a significant degree of gender bias persists in the two areas analyzed. From these results we derived some strong implications for equality policies.

Keywords

Career recommendations; STEM studies; engineering; gender bias; double standards

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1. Introduction

Overall, women remain under-represented in engineering and technology. In Spain, they represented 23% of the engineering and technology research staff of public universities in 2015 (MEIC 2016). In Colombia, women represented 25% of all researchers in engineering and technology (UNESCO 2018).

These figures are consistent with low female enrollment rates in courses in this field. For example, in Spain women represented 21.15% of the total number of students enrolled in mechanical engineering in the 2016-2017 academic year, and 11.9% of those enrolled in computer engineering (MECD 2018). In Colombia, in 2017 women accounted for 26% of all those enrolled in engineering studies (SNIES 2018).

Mathematical ability is considered a prerequisite for students wanting to enroll for technological courses (Sáinz and Eccles 2012), in a context in which math-gender stereotypes that disadvantage girls persist (Cheryan 2012; Shapiro and Williams 2012; UNESCO 2017).

Research shows that the disadvantage faced by girls in technological STEM is the result of the interaction of a range of factors embedded in both the socialization and learning processes. As expectancy-value theory (Eccles et al. 1983) and ecological framework (Bronfenbrenner 1979) suggest, these include social, cultural and gender norms which influence the way girls and boys are brought up, learn and interact with parents, family, friends, teachers and the wider community, and which shape their identity, beliefs, behavior and choices (UNESCO 2017).

The beliefs and expectations of parents, teachers and other tutors can have an important effect on mathematics self-concept and on the career choice of girls and boys (Gunderson et al. 2011). However, the beliefs, attitudes and expectations of parents and tutors are themselves influenced by gender stereotypes or, in the words of Charles and Bradley (2009), by "the enduring cultural force of gender-essentialist ideology (i.e., cultural beliefs in fundamental and innate gender differences)".

In this research we focus specifically on the detection of possible biases (derived from the existence of these stereotypes) that tutors may have when assessing the mathematical ability of teenagers or when advising them on their career choice. Indeed, our study has three research aims: first, to capture and quantify experimentally the bias (exerted by potential tutors) in favor of a young male target (compared to a young female target) in the attribution of mathematical ability. Second, to detect and quantify the gender bias (in favor of the male target) in the recommendation to study engineering. Third, to determine to what extent this biased recommendation is related to the bias in the attribution of mathematical ability.

For this purpose we conducted a controlled experiment to directly detect these biases. We presented a fictional profile of a 15-year-old person to the participants in our study (university students from Spain and Colombia) and asked them to evaluate his/her mathematical ability and advise him/her about whether or not to study engineering in the future. Our design was a 2x2 factorial where factor 1 was the gender of the target (male, female) and factor 2 was the level of the academic record of the target (intermediate, high).

After a random assignment of the participants to each of the four resulting experimental conditions, we were able to obtain causal evidence about the biases discussed previously (the fact that the target was called Manuel or María causally influenced the evaluations and recommendations of the participants).

We consider that both the specific phenomenon to be studied and the experimental methodology used constitute a totally novel contribution to the literature on gender and the choice of a STEM career.

Our study also contains a cross-cultural dimension, using two samples of Spanish (Madrid) and Colombian (Barranquilla) participants. These two countries have a number of aspects in common, such as a similar population (46.5 million inhabitants in Spain, 49.0 million in Colombia, in 2017, according to World Bank 2018), the same main language (Spanish), and certain historical and cultural affinities.

However, there are also important differences in terms of geographical location, historical evolution, economic and social development, and social, cultural and gender norms. In Colombia there is greater persistence of traditional gender norms. For example, 71.4% of Spanish respondents but only 41.0% of Colombian respondents disagreed with the statement "If a woman earns more money than her husband, it's almost certain to cause problems", made by the World Values Survey (2014).

In addition, these cross-cultural differences can be intensified by comparing the specific social and cultural environment of Madrid (belonging to a central and rich region of Spain) with that of Barranquilla, belonging to the Caribbean Coast region of Colombia.

2. Theoretical justification

2.1. Expectancy-value theory of achievement and choices and parent and tutor influence

The analysis of the influence of tutors (parents, older siblings, teachers, etc.) in the choice of courses taken by adolescents can be addressed through expectancy-value theory (EVT) (Eccles et al. 1983; Eccles 2014). EVT is a theoretical framework that uses both psychological and socio-cultural perspectives on human development to explain human (in this case young student) choice and achievement.

According to EVT, students' achievements and achievement-related choices are most proximally determined by two factors: expectancies for success (“am I able to do this task?”) and subjective task values (“why should I do this task?” “What value do I give to this activity?”).

Expectancies for success collect students’ beliefs about how well they will do in an upcoming task. The subjective value component can be divided into five subcomponents: interest (the enjoyment experienced when doing a task or interest in the content of a task); utility value (the usefulness of a task for future goals); attainment value (the importance of doing well on a task); relative cost; (opportunity cost, emotional cost, etc., of doing a task); and prior investment (prior experience and effort investment in this task).

Students’ goals and general self-schemas (personal and social identities, possible and future selves, self-concept, short and long-term goals) affect expectancies and value. The value component is also affected by the “student’s affective reactions and memories”.

However, if we take a step back in the model, these student goals and affective reactions are influenced by their perceptions and interpretations of experience. A student’s perceptions include the perception of the beliefs, gender roles and stereotypes of the socializers (tutors).

These last two factors and, ultimately, the choice of course for adolescents, are influenced by a number of factors: cultural milieu, stable child characteristics, previous achievement-related experiences, and socializer beliefs and behaviors.

The EVT has a certain parallelism with the "ecological framework" of factors influencing the participation, achievement and progression of girls and women in STEM studies (UNESCO 2017), which distinguishes between multiple and overlapping factors (society, school, family and peers, and learner). In both cases, what stands out is that advice from tutors (parents, older siblings, teachers) can play an important role in the child's perceptions and choices.

There is a considerable literature that confirms the influence of parents and other tutors in the formation of adolescents’ attitudes to mathematics and their choice of course (Eccles et al. 1993; Eccles 2014). According to Jodl et al. (2001) who conducted research on a sample of 444 American adolescents, parental values predicted adolescents’ occupational aspirations via both direct (parental values) and indirect (parental behavior) pathways. When adolescents perceive their parents to have high educational expectations for them, they are more likely to have higher aspirations for themselves (Davis-Kean, 2005; Sáinz and Müller 2017). Parental social status and education are also important predictors of adolescent educational and behavioral outcomes (Boudarbat and Montmarquette 2009; Sáinz and Müller 2017).

2.2. Social role theory. The origin of stereotypes

A large body of work has shown that there is still a stereotype that associates mathematical ability with men to a greater extent than with women (Gunderson et al. 2012). And, at the same time, the persistence of an important degree of gender segregation in the fields of study continues to be observed (Charles and Bradley 2009). What underlies these phenomena is the persistence of a series of gender stereotypes that, logically, are also held by parents and tutors (and that they subsequently transmit to their children or wards).

Where could these essentialist beliefs of the tutors originate? According to social role theory (Eagly, 1987; Eagly and Karau, 2002), it is not so much that the differences (essential, natural) between men and women explain the inequalities we see in the results (in power, in gender roles ...), rather the opposite. The starting point is that there are inequalities that manifest themselves in the performance of different roles and, in an attempt to explain why these roles exist, we make essentialist attributions ("because men and women are different ..."). The basic principle of social role theory is that gender differences and similarities arise primarily from the distribution of men and women into social roles within their society. That means that perceivers infer that there is correspondence between the types of actions people engage in ("there are many men in engineering and technology activities") and their inner dispositions ("so men are better engineers and mathematicians"). Thus gender stereotypes follow from the observation of people in typical social gender roles—especially, men's occupancy of the breadwinner and higher status roles (with perceivers attributing agentic traits to them) and women's occupancy of homemaker and lower status roles (with perceivers attributing communal traits to them). This is, in fact, an application of "fundamental attribution error", according to which we tend to attribute other people's actions to their personality characteristics.

In addition, these stereotypes, such as that regarding mathematics and language, can be explicit or implicit (Nosek et al. 2009). For instance, Smeding (2012) found that implicit gender-mathematics stereotypes —measured by an implicit association test— were weaker among female engineering students than female humanities students.

In the case of Spain, Sáinz et al. (2012), in qualitative research, analyzed how parents and teachers perceived ICT professionals. On the one hand, these tutors considered that gender does not condition adolescents' study choices; but, on the other, they held several kinds of stereotypes about ICTs, some of them related to gender (for example, some teachers assumed that girls frequently had better grades because they were more hard working and responsible than their male counterparts, whereas when discussing high achieving students, the highest intellectual capabilities were assigned to boys).

Regarding the specific content of stereotypes (maintained by tutors and other socializers), there are two predominant stereotypes in relation to gender and STEM (Hill et al. 2010; UNESCO 2017) –"boys are better at maths and science than girls" and "science and engineering careers are masculine domains".

2.3. Double standards, status characteristics theory and the measurement of gender biases

Our procedure to detect possible gender biases in the attribution of mathematical ability and in the recommendation to study engineering can be understood in terms of the "double standards" approach. Double standards is the practice of using different requirements to interpret the same evidence and, in particular, applying stricter requirements to members of devalued groups (Foschi 2000).

Status characteristics theory (SCT) directly addresses the double standards phenomenon. As defined by SCT (Correll and Ridgeway 2003; Correll et al. 2007), a status characteristic is a categorical distinction among people (for instance, depending on their gender), that has attached to it widely held beliefs in the culture that associate greater status worthiness and competence with one category of the distinction (men) than with another (women). A status characteristic becomes salient when it differentiates those in the setting or because the characteristic is believed to be directly relevant to the task at hand ("men have a greater facility for mathematics"). The theory argues that actors then implicitly use the salient characteristic to guide their behavior and evaluations. The result is biased evaluations, where a stricter standard is used when evaluating the lower status group (in our experiment, the female target).

In our research we also consider the possibility that gender biases, or double standards, may vary depending on the level of the target's academic record. We think that the margin that participants have to interpret what is the mathematical ability or the suitability of the target to study engineering is greater when the target has an intermediate academic record than when he/she has a high one. For this reason, it seems plausible that greater biases may appear in the first case than in the second. We call this phenomenon "differential double standards".

There is an important experimental literature aimed at detecting gender biases (double standards) in the labor market. For instance, in the laboratory experiment of Correll et al. (2007), participants evaluated application material for a pair of same-gender equally qualified job candidates who differed in their parental status. They found that mothers (compared with non-mothers) were penalized on a host of measures (perceived competence, recommended starting salary, etc.). A similar result was obtained in the experimental research of Cuddy et al. (2004). On the other hand, in Vandello et al. (2013), based on an experimental design similar to that of Cuddy et al. (2004), participants evaluated hypothetical targets who sought a flexible work arrangement after the birth of a child. Flexibility seekers were given lower job evaluations than targets with traditional work arrangements (flexibility stigma). Other studies in this line are those of Fuegen et al. (2004), Moss-Racusin at al. (2010, 2012), and Rudman and Mescher (2013).

Following this line of experimental research, in this article we intend to use a design with some aspects in common with that of Cuddy et al. (2004) and Vandello et al. (2013). However, in our research participants have to evaluate mathematical ability and have to recommend to a greater or lesser extent a series of university degrees to each of the four targets (four profiles of a 15 year old student). In other words, in the other studies the objective was to detect and quantify gender biases in the evaluation of the professional merits of the targets, while in our research we try to detect gender biases in the attribution of mathematical ability and the recommendation to study engineering. Our experimental design is completely new both within the experimental literature, just quoted, and in the literature on girls and women in STEM.

2.4. Hypotheses

Hypothesis 1. There is a gender bias in the attribution of mathematical ability. Faced with an identical target (a fictitious 15 year old student), the participants (on average) attribute a greater degree of mathematical ability to the male target than to the female target.

Hypothesis 2. There is a gender bias in the recommendation to study engineering. Faced with an identical target (a fictitious 15 year old student), the participants (on average) recommend studying engineering more to the male target than to the female target.

Hypothesis 3. The perception that the target has more mathematical ability positively influences the recommendation to study engineering. The perception that the target has more mathematical ability is a mediating variable in the total effect of the target's gender on the recommendation to study engineering. Indeed, being a male target has a direct positive effect on the participant’s recommendation (to the target) to study engineering, but it also has an indirect positive effect through an attribution (to the target) of greater mathematical ability.

Hypothesis 4. Gender biases (in attributing mathematical ability and recommending engineering) can take the form of differential double standards. These gender biases (or double standards) in favor of the male target can be higher when the target’s academic record is intermediate compared to when it is high (the participants penalize the male target less than the female target for having an academic record that is not high).

Hypothesis 5. In a more traditional society (in particular in gender attitudes), such as that of Barranquilla, compared with that of Madrid, the intensity with which both biases are manifested is greater.

3. Method

3.1. Participants

1,714 university students participated in the experiment. 754 were in the Universidad Complutense de Madrid and in the Universidad Politécnica de Madrid, both located in the region of Madrid, Spain; and 960 were in the Universidad del Norte, located in the Caribbean Coast region, Colombia. Sampling was performed in each institution separately (following the same protocol), during the period February 2018-May 2018. All the participants were studying bachelor or master's degrees (411 in the field of engineering, 706 in the fields of social sciences and humanities, and 597 in the field of health sciences). 856 were female students and 858 were male students. In the Spanish sample 10.8% of the students were immigrants and 7% were foreign students; in the Colombian sample these figures were 0.9% and 0.8% respectively. The average age of participants was 21.6 in Spain and 22.4 in Colombia.

3.2. Design

Our design is a "posttest-only 2x2 factorial, randomized block design with two groups of blocks" (Trochim et al. 2016). Factor 1 is the gender of the target (male, female) and factor 2 is the level of the academic record of the target (intermediate, high). The two blocks are the participant's gender (male, female) and the participant's study field (engineering, social sciences and humanities, health sciences).

3.3. Materials and variables

3.3.1. Questionnaire

Participants had to complete one questionnaire (in the Spanish language). It presented participants with a brief description of a fictitious 15-year-old student (called María or Manuel, very common female and male names in Spain and Colombia). The target was described as a 15-year-old student studying the last year of compulsory secondary education, in a "colegio concertado" (private but public funded school) in the case of Spain, and in a private school in the case of Colombia. The description also included the academic record of the student for the current academic year. There were two levels of academic record (high, with an average grade of 8.95 on a scale of 0 to 10; and intermediate, with an average grade of 6.95). The structure of the grades, or relative grades (of the 11 subjects that appear in the academic record) was kept constant across the two academic record levels (the detailed presentation of these academic records is in the appendix). There was also some gender-neutral information about the target's personality traits and tastes ("Manuel/María is a rather reflective, curious person; with an open mind about knowledge and new experiences. He/she likes music and movies. He/she plays tennis and paddle tennis").

At the top of the questionnaire, among other things, participants were told "Please read the profile description of this student carefully. Imagine that you are one of his/her tutors and that this student has asked you for a (university degree choice) recommendation. What recommendation would you give him/her taking into account what you have read about his/her academic record, hobbies, etc. and your criteria about what you consider to be the most suitable university degrees for a student with these characteristics?"

After the description of the target, the questionnaire contained questions about career recommendations and the mathematical ability of the target. In addition, a set of demographic questions was added.

3.3.2. Recommendation scales

Following the description, participants rated 19 university degrees. They were asked "In the next 19 questions you are asked to indicate the extent to which you would advise Manuel/María to choose each of these careers". The response scale ranged from 1 ="I would strongly advise against it" to 10="I would strongly advise it". These 19 careers are listed in tables 1 and 2. In our analysis we are only going to use these two single item scales as dependent variables: "recommend mechanical engineering" (range of values from 0 to 10) and "recommend computer engineering" (range from 0 to 10).

3.3.3. Mathematical ability scale

Next, the students were asked "despite the little information you have, do you think that Manuel/María is equally qualified for mathematical reasoning and for verbal expression and communication?". The response options were: 1 = "Manuel/María has much less talent for mathematics than for verbal expression and communication"; 2= "… has less talent for mathematics than for verbal…"; 3= "… has the same talent for mathematics as for verbal…"; 4= "… has more talent for mathematics than for verbal…"; and 5 = "… has much more talent for mathematics than for verbal…". The single item variable "mathematical ability" (ranging from 1 to 5) is the third dependent variable in our study.

3.3.4. Factors and blocks.

There are two factors:

“Male target”, a dichotomous variable (1=Manuel; 0=María).

“High academic record”, a dichotomous variable (1=high academic record; 0= intermediate academic record).

And two blocks:

“Study areas”, the field that the participant is studying. It has three categories (1=engineering; 2=social sciences and humanities; 3=health sciences). In fact, we grouped a broader set of courses taken by the participants into these three categories. In the case of Spain, these were: Civil and Territorial Engineering, Computer Science Engineering; Economics, Business Administration and Management, Banking and Quantitative Finance, Actuarial and Financial Science (master), Business Finance (master); English Studies, Philosophy; Medicine, Pharmacy, and Biology. In the case of Colombia, Industrial Engineering, Electrical and civil Engineering; Economics, Business Administration, Tourism, Political Science, International relations, Sociology, Social Communication; Medicine, Psychology, Chemistry, and Nutrition.

“Female participant”, a dichotomous variable (1=female participant; 0=male participant).

3.3.5. Other variables

Finally, in the path analysis we wanted to control for the effect of several variables. “Age” (age in years); “religiosity scale”, which is the answer (on a scale 0-10) to the question "on the following religiosity scale, which ranges from 0 (not religious) to 10 (very religious), where would you place yourself? We also used the following dummy coded (1=yes; 0=no) variables: “Health sciences” (the participant was doing studies in the field of health science); and “social sciences” (the participant was doing studies in the field of social sciences or humanities).

3.4. Procedure

The questionnaires were distributed in class to the students who decided to participate voluntarily in the experiment. The four experimental conditions were randomly assigned (male-high=25.20%; female-high=25.26%; male-intermediate=24.68%; female-intermediate=24.85%). The questionnaires were administered at the beginning of the corresponding class, with the teacher's permission. The average time to complete the questionnaire was 10 minutes. The same protocol was followed in all three universities. When giving instructions on how to fill out the questionnaire, among other things the researchers guided the participants saying "please, do not put what you would like to study, but what you would recommend to a young person with the characteristics that we are going to show you in the questionnaire".

4. Results

The analysis of gender biases in the attribution of mathematics ability and the recommendation of university careers was carried out following these three steps: Descriptive analysis, general linear model (GLM) univariate analysis, and path analysis with mediating and moderating variables.

4.1. Descriptive analysis

Tables 1 and 2 show (for Spain and Colombia, respectively) the average scores obtained for each of the 19 careers (recommendation scales) included in our design. We also provide the male-female score ratio, ordered from highest to lowest male-female recommendation ratio.

In Spain the two highest male-female ratios correspond to "recommend mechanical engineering" (M-F ratio=132.4%) and "recommend computer engineering" (M-F ratio=131.8%). Indeed, in the case of "recommend mechanical engineering", there was a highly significant difference in the average scores for "Manuel" (M=5.696, SD=3.056) and María (M=4.302, SD=3.124); t(760)=6.122, p=0.000. In the case of "recommend computer engineering" the result was very similar.

In Colombia, high male-female ratios were also obtained for the two engineering careers (120.2% and 119.7% respectively). However, even higher male-female ratios were obtained for "recommend business administration" (146.5%) and "Recommend economics" (143.8%). For instance, in the case of "recommend business administration", the difference in the average scores for Manuel (M=6.539, SD=2.192) and María (M=4.464, SD=2.656) was very large; t(961)=13.316, p=0.000. This result may indicate that in an environment such as that of Barranquilla, business management and activities related to economics are perceived as markedly masculinized activities (much more than in the Madrid environment).

The results of tables 1 and 2 show that, for both the Spanish and Colombian samples, there is a clear gender pattern in the recommendation of careers to our target student. More technology-related careers are recommended to a greater extent to Manuel, while several careers stereotyped as feminine are recommended to a greater extent to María. It is noteworthy that the two careers with more bias in favor of Maria (primary education and fine arts) are the same in Spain and Colombia. On the other hand, these biases seem to be more intense in the case of the Colombian sample (which points to hypothesis 5 holding).

It is also worth noting that, within STEM, the gender bias is detected more in technology-related careers and not so much in those related to health sciences.

These first results point to the confirmation of hypothesis 2 in this investigation.

Regarding "mathematical ability", there is a gender bias in the attribution of mathematical ability in the two samples (hypothesis 1). However, the bias is considerably greater in the Colombian sample (Manuel: M=3.798, SD=1.042; María: M=3.228, SD=1.249; t(961)=7.565, p=0.000) than in the Spanish one (Manuel: M=3.022, SD=0.688; María: M=2.895, SD=0.648; t(751)=2.574, p=0.010). This is reflected in a M-F ratio of 117.7% in Colombia and 104.4% in Spain.

Table 1. Differences in recommendations for majors by male/female target (19 majors). Spanish students

	Male-female ratio		Female target		Male target		Total		
			N	Mean	N	Mean	N	Mean	SD
Recommend mechanical engineering	**132.4%**	***	384	**4.302**	369	**5.696**	753	4.985	3.167
Recommend computer engineering	**131.8%**	***	384	**4.581**	369	**6.035**	753	5.293	3.121
Recommend physics	**116.4%**	***	384	**5.010**	369	**5.832**	753	5.413	2.825
Recommend chemistry	**110.3%**	**	384	**5.232**	368	**5.769**	752	5.495	2.628
Recommend architecture	**106.2%**		385	**4.958**	369	**5.266**	754	5.109	2.641
Recommend economics	**103.5%**		385	**5.351**	369	**5.539**	754	5.443	2.497
Recommend business administration	**102.7%**		385	**5.075**	369	**5.211**	754	5.142	2.798
Recommend sport sciences	**102.2%**		385	**4.335**	369	**4.431**	754	4.382	2.886
Recommend medicine	**101.0%**		384	**6.247**	369	**6.312**	753	6.279	2.849
Recommend biology	**100.0%**		385	**5.860**	368	**5.861**	753	5.861	2.449
Recommend law	**97.2%**		383	**5.274**	368	**5.128**	751	5.202	2.633
Recommend history	**96.0%**		384	**4.602**	369	**4.417**	753	4.511	2.808
Recommend social work	**95.3%**		383	**5.603**	369	**5.339**	752	5.473	3.100
Recommend pharmacy	**95.2%**		385	**5.816**	368	**5.535**	753	5.679	2.661
Recommend psychology	**93.6%**	*	385	**7.140**	369	**6.686**	754	6.918	2.343
Recommend journalism	**92.7%**	*	385	**6.496**	369	**6.019**	754	6.263	2.820
Recommend philology	**91.1%**		385	**4.912**	369	**4.477**	754	4.699	2.960
Recommend primary education	**89.0%**	**	385	**5.481**	368	**4.878**	753	5.186	2.924
Recommend fine arts	**88.3%**	*	385	**5.088**	369	**4.493**	754	4.797	3.087
Mathematical ability	**104.4%**	*	381	**2.895**	364	**3.022**	745	2.957	0.671

T-test for difference of means- P-values: *p<0.05; **p<0.01; ***p<0.001

Table 2. Differences in recommendations for majors by male/female target (19 majors). Colombian students

	Male-female ratio		Female target		Male target		Total		
			N	Mean	N	Mean	N	Mean	SD
Recommend business administration	**146.5%**	***	474	**4.464**	486	**6.539**	960	5.515	2.643
Recommend economics	**143.8%**	***	474	**4.481**	486	**6.444**	960	5.475	2.742
Recommend mechanical engineering	**120.2%**	***	474	**4.382**	486	**5.265**	960	4.829	2.591
Recommend computer engineering	**119.7%**	***	474	**4.289**	486	**5.136**	960	4.718	2.631
Recommend physics	**119.2%**	***	474	**4.200**	486	**5.008**	960	4.609	2.658
Recommend architecture	**113.9%**	***	424	**4.922**	486	**5.605**	910	5.287	2.345
Recommend law	**112.9%**	***	474	**5.194**	486	**5.866**	960	5.534	2.755
Recommend chemistry	**105.2%**		474	**4.854**	486	**5.107**	960	4.982	2.516
Recommend sport sciences	**105.1%**		474	**4.310**	486	**4.531**	960	4.422	2.182
Recommend medicine	**103.1%**		474	**4.705**	486	**4.852**	960	4.779	2.417
Recommend psychology	**96.9%**		474	**5.466**	486	**5.298**	960	5.381	2.563
Recommend pharmacy	**95.1%**		474	**4.928**	486	**4.685**	960	4.805	2.491
Recommend biology	**93.2%**	*	474	**4.669**	486	**4.350**	960	4.507	2.345
Recommend history	**87.6%**	***	474	**6.430**	486	**5.634**	960	6.027	2.471
Recommend social work	**83.2%**	***	474	**6.285**	486	**5.226**	960	5.749	2.635
Recommend journalism	**82.8%**	***	474	**6.306**	486	**5.220**	960	5.756	2.504
Recommend philology	**75.6%**	***	474	**5.681**	486	**4.294**	960	4.979	2.480
Recommend primary education	**72.0%**	***	474	**5.920**	486	**4.263**	960	5.081	2.610
Recommend fine arts	**69.5%**	***	474	**6.302**	486	**4.377**	960	5.327	2.594
Mathematical ability	**117.7%**	***	474	**3.228**	486	**3.798**	960	3.517	1.183

T-test for difference of means- P-values: *p<0.05; **p<0.01; ***p<0.001

4.2. General linear model (GLM) univariate analysis

We conducted a general linear model (GLM) univariate analysis with SPSS (Arbuckle 2017). The GLM univariate procedure provides an analysis of variance for one dependent variable by one or more factors and/or variables (we can investigate interactions between factors as well as the effects of individual factors). We proceed as follows: First, our dependent variables will be “recommend mechanical engineering”, “recommend computer engineering” and “mathematical ability”. Second, since our experimental design consists of a "2x2 factorial", the factors being the target's gender and the target's academic record, in all cases we incorporate the main effects of these two factors plus the interaction between them. Third, if any of the two blocks (participant's gender and participant's study field) have a statistically significant main effect, we incorporate them into our GLM. And fourth, if there is any statistically significant interaction between any of the factors and any of the blocks, then we incorporate that interaction into our GLM analysis.

For the sample of Spanish students, table 3 shows that both the target’s gender ($F(1, 747)= 42.842$, $p<.001$) and the target's academic record ($F(1, 747)= 79.315$, $p<.001$) had a significant effect on "recommend mechanical engineering". On the other hand, the "male target*high academic record" interaction did not have a statistically significant effect. Finally, the "study area" block also had a significant effect ($F(2, 747)= 9.089$, $p<.001$). The latter is due to the fact that the participants belonging to the study area of engineering recommended studying mechanical engineering more than the rest of participants.

These results are shown in figure 1. The positive slope of the two lines shows that the "male" experimental condition increased the degree to which the participants recommended studying mechanical engineering. The vertical distance between the two lines shows that the experimental condition "high academic record" also increased the degree to which participants recommended studying mechanical engineering. In turn, the fact that both lines are parallel shows that, for the Spanish sample, there is no interaction between the target’s gender and the target’s academic record.

For the dependent variable "recommend computer engineering" a very similar result is obtained (see figure 2).

For the Colombian sample, table 3 and figures 4a and 5a show that the target’s gender had a significant effect on "recommend mechanical engineering" ($F(1, 950)= 24.658$, $p<.001$) and on “recommend computer engineering” ($F(1, 950)= 35.680$, $p<.001$). The target's academic record had a significant effect on "recommend mechanical engineering" but not on “recommend computer engineering” (the two lines are very close). The "study area" block also had a significant effect in both cases.

It should also be noted that for the Colombian sample there are several statistically significant interactions. First, the “male target*high academic record” interaction is significant for the case of “recommend computer engineering”. As the different slopes in figure 5a show, the bias in favor of the male target in the recommendation to study computer engineering is greater when the target's academic record is not high. This means that participants penalize the male target less than the female target for having an academic record that is not high (differential double standards).

Second, “male target*study areas” has a significant effect on both "recommend mechanical engineering" and "recommend computer engineering". However, looking at the figures we can see that this happens for two different reasons. As shown in figure 4b, in the case of "recommend mechanical engineering" the participants who were studying engineering (industrial, electrical and civil engineering) did not present a bias in the recommendation in favor of the male target. This lack of bias may have to do with the fact (rather atypically for Colombian standards) that among these engineering students the percentage of women was quite high (which could imply a certain "role model" effect that neutralizes the masculine bias in the recommendation of the career that they are studying). On the other hand, as shown in figure 5b, when recommending studying computer engineering (by the participants who were studying engineering), a course which they themselves are not studying, the bias in favor of the male target reappears, even more strongly than among the participants who were studying majors in the field of Social Sciences and health science.

Third, the significant effect of the "high academic record*study areas" interaction, both for "recommend mechanical engineering" and for "recommend computer engineering", is noteworthy. As can be seen in figures 4c and 5c, participants who study health sciences present anti-intuitive recommendations, contrary to the recommendations of the rest of the participants from Colombia and Spain: If the target has a high academic record, then they recommend studying engineering to a lesser extent. Perhaps this is because these students (of majors of high scientific prestige, such as medicine), consider that high performance students should study careers like medicine, biology, etc., instead of careers such as engineering.

Regarding "mathematical ability", the estimations obtained through the GLM confirm those obtained in the previous section: for both Spanish and Colombian samples, there is a gender bias in favor of the male target in the attribution of mathematical ability (figures 3a and 6). In addition, and as expected, a greater mathematical ability is attributed to the targets with a high academic record.

In the case of Colombia, both male and female participants have a similar bias. However, this is not the case for the Spanish participants. Table 3 indicates that in this case there is a statistically significant "male target*Female participant" interaction. As the examination of Figure 3b shows, the bias in favor of the male target in the attribution of mathematical ability only occurs among male participants.

Finally, in the case of the Colombian sample, a significant effect of the "male target*High academic record" interaction is obtained. As figure 6 shows, the gender bias in the attribution of mathematical ability (in favor of the male target) is higher when the target’s academic record is intermediate compared to when it is high. This is again evidence of the differential double standards phenomenon.

From the causal inference exercise we have carried out, the results obtained in this section support hypotheses 1 and 2 quite robustly (the participants in our experiment have a gender bias in the attribution of mathematical ability and in the degree to which they recommended studying engineering) and in two cases this bias is accompanied by a "differential double standards" phenomenon (hypothesis 4).

Table 3. General Linear Model analysis for Spanish and Colombian participants

Spanish students						
	Recommend **mechanical engineering**		Recommend **computer engineering**		**Ability for mathematics**	
	F		F		F	
Male target	42.842	***	46.537	***	7.895	**
High academic record	79.315	***	48.406	***	38.463	***
Male target * High academic record	.144		.454		.032	
Study areas	9.089	***	10.308	***	-	
Female participant	-		-		1.973	
Male target * Female participant	-		-		5.403	*
Adjusted R-squared	0.154		0.130		0.062	

Colombian students						
	Recommend **mechanical engineering**		Recommend **computer engineering**		**Ability for mathematics**	
	F		F		F	
Male target	24.658	***	35.680	***	68.352	***
High academic record	11.201	***	.144		133.467	***
Male target * High academic record	0.439		7.702	**	6.294	*
Study areas	30.848	***	134.482	***	-	
Male target * Study areas	8.127	***	5.492	**	-	
High academic record * Study areas	117.199	***	46.495	***	-	
Male target * High academic record * Study areas	-		11.991	***	-	
Adjusted R-squared	0.262		0.308		0.175	

P-values: *p<0.05; **p<0.01; ***p<0.001

Figure 1. Differences in the recommendation to study mechanical engineering according to the two factors. Spanish Students.

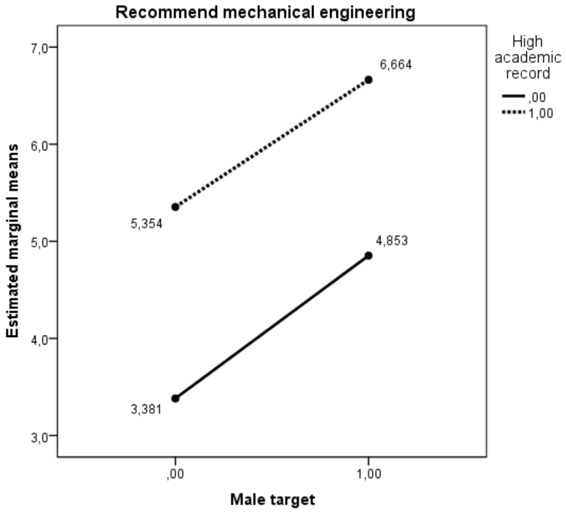


Figure 2. Differences in the recommendation to study computer engineering according to the two factors. Spanish Students.

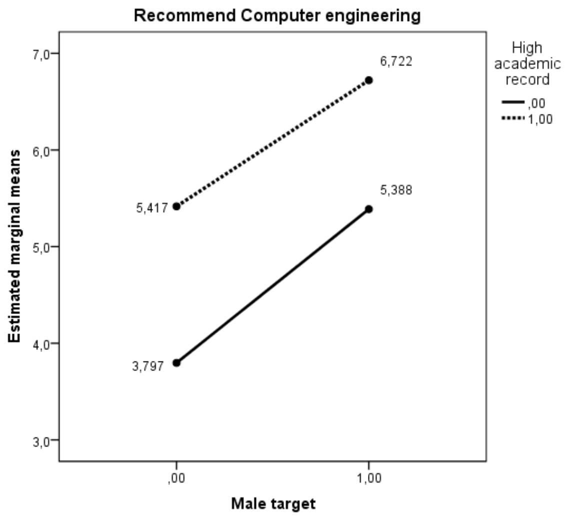


Figure 3. Differences in the perception of target's capacity for mathematics according to the two factors. Spanish Students.

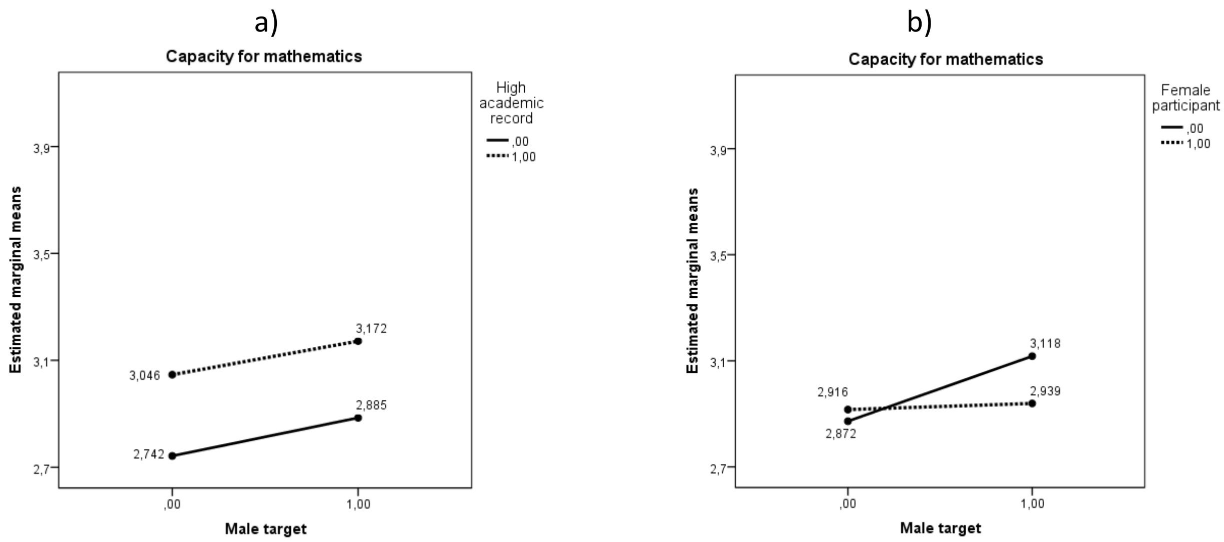


Figure 4. Differences in the recommendation to study mechanical engineering according to different factors. Colombian Students

a) b) c)

Figure 5. Differences in the recommendation to study computer engineering according to different factors. Colombian Students

a) b) c)

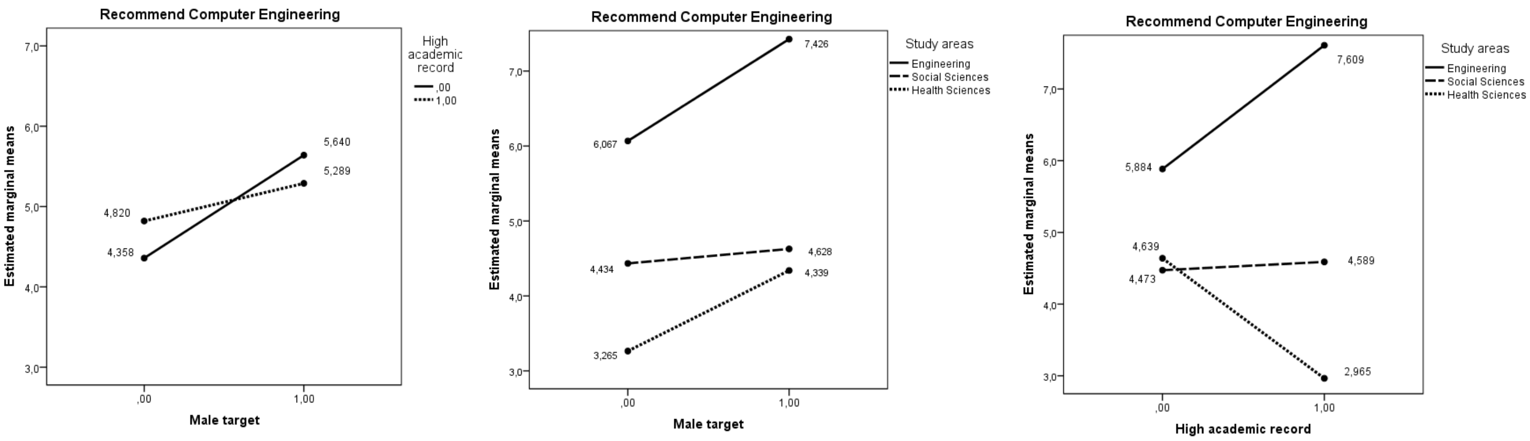
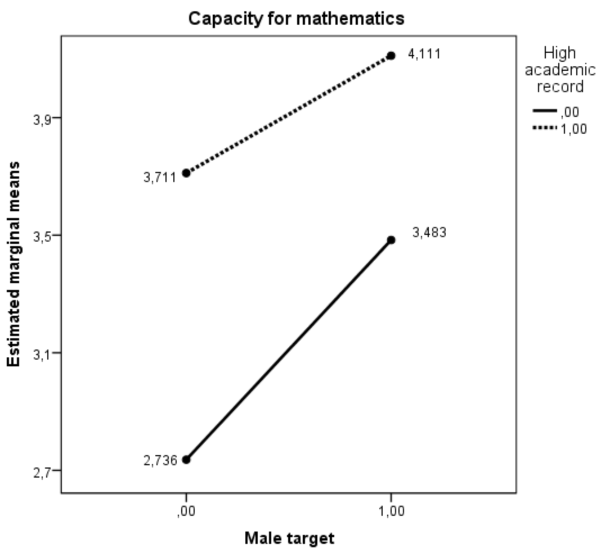


Figure 6. Differences in the perception of target's capacity for mathematics according to different factors. Colombian Students



4.3. Path analysis: Mathematical ability as a mediating variable

In this section we want to test the hypothesis 3 (mathematical ability is a mediating variable in the total effect of the target gender on the recommendation to study engineering). For this, we run a multigroup path analysis (through structural equation modeling) for the dependent variable "recommend mechanical engineering" and "recommend computer engineering" (figure 7). The model has two main characteristics: first, it is a simple mediation model with two consequent outcome variables. Second, similar to what we did in the previous section, in several of the paths we introduce a series of moderating variables (the effect of “male target” on “mathematical ability” is moderated by “female participant” and “high academic record”; the effect of “mathematical ability” on “recommend mechanical engineering” is moderated by “health sciences”; and the effect of “mathematical ability” on “recommend mechanical engineering” is moderated by “health sciences” and “social sciences”). These moderating variables also appear in figure 7.

The path analysis was performed with the Amos 25.0 program (Arbuckle 2017). Multigroup analysis allows to analyze the question of whether a path in the model has a different effect in Spain than in Colombia.

The path analysis model presents quite acceptable fit ($\chi2(44)=34.819$, $p=0.837$; TLI=1.003; RMSEA=.000; CFI=1.000).

We reject the null hypothesis that the corresponding models for Spain and Colombia are identical ($\chi2(45)=495.106$, $p=0.000$), which means that the participant’s country moderates the results obtained.

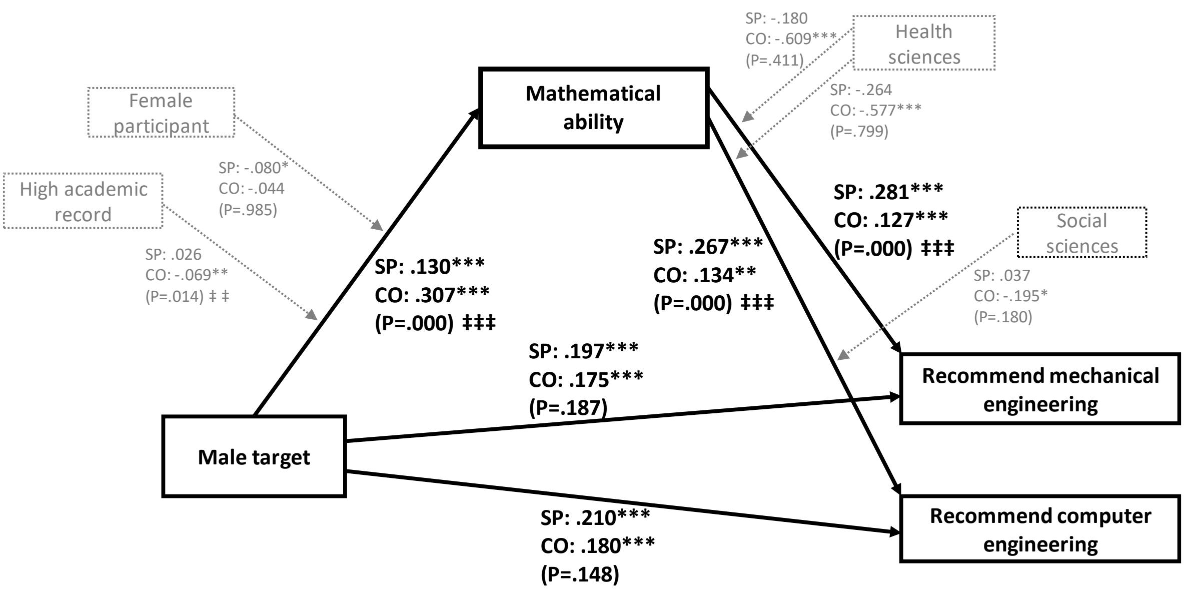
“Male target” has a statistically significant positive direct effect on “recommend mechanical engineering” in Spain (.197) and in Colombia (.175). But it also has a statistically significant positive indirect effect on “recommend mechanical engineering” through the mediating variable “mathematical ability”. Indeed, “male target” has a statistically significant positive effect on “mathematical ability” (only for male participants, in the case of Spain; with a more intense effect when the target has an intermediate academic record, in the case of Colombia). And “mathematical ability” has a statistically significant positive effect on “recommend mechanical engineering” (only for participants who studied engineering and social sciences, in the case of Colombia). For example, when the participant is male, the study area is not health sciences and the academic record is intermediate, the conditional indirect effect of “male target” on “recommend mechanical engineering” is .037 for Spain and .039 for Colombia.

For the direct and indirect effects of "male target" on "recommend computer engineering", very similar results are obtained.

The reason why in Colombia the participants who study health sciences present anti-intuitive result (they do not recommend studying engineering to a higher extent to those who have more mathematical ability) could be that these students (of majors of high scientific prestige, such as medicine) consider that high performance students (with higher mathematical ability) should study careers like medicine, biology, etc., instead of careers such as engineering.

In short, the path analysis performed in this section seems to support hypothesis 3: being a male target has a direct positive effect on the participant's recommendation (to the target) to study engineering, but it also has an indirect positive effect through an attribution (to the target) of greater mathematical ability.

Figure 7. "Mathematical ability" as a mediating variable. Multigroup path analysis for Spanish and Colombian samples.



Spain, N = 754; Colombia, N=960. Standardized Regression Weights are provided for each path. Sp: Spain; Co: Colombia. *0.10; **0.05; ***0.01. P-value for critical ratios for differences between each pair of regression weights (for Spain and Colombia) are provided for each path: ‡ p<.10; ‡‡ p<.05; ‡‡‡ p<.01. Control variables: "Age", "religiosity scale", "high academic record" and "social sciences".

5. Discussion

We have offered causal empirical evidence about the existence of a gender bias in the attribution of mathematical ability and in the recommendation to study engineering. Presenting the same information about a 15-year-old target person with a female or male name activated the existing gender stereotypes concerning girls and technological

STEMs. This led (on average) to a biased attribution of mathematical ability and to a biased recommendation to study engineering, both in favor of the target with a male name. For instance, among Spanish participants, the degree to which they recommended that the target study mechanical engineering was on average 32.4% higher when the target was called "Manuel" than when they were called "María". In the case of computer engineering (figure 2), when the male target had an intermediate academic record, the estimated marginal mean (for recommend computer engineering) was 5.388, while the figure corresponding to the female target was very similar (5.417), but only when she had a high academic record. Expressed in terms of double standards: on average, female targets need a higher academic record before they are recommended to study engineering with the same intensity as male targets.

We have also shown that, in fact, the biased attribution of mathematical ability is one of the mechanisms (mediating variable) through which the target's male or female name influences the participants' recommendations to study engineering.

In the context of the EVT, there is a substantial body of research (Sáinz et al. 2012; Eccles 2014) about how parents, teachers, and tutors transmit their beliefs and attitudes, and shape female and male adolescents' choice of course. However, the process through which existing stereotypes generate biased attributions or recommendations made by tutors has not been widely studied. Thus, we consider that our experimental analysis contributes to generating new knowledge regarding one of the elements included in the EVT framework.

The cognitive process (raised by the SCT) through which the target having a female or male name activates existing gender stereotypes can be captured using Bem's theory of gender schema (Bem 1981; Sáinz et al. 2012). According to this approach, gender schemas allow individuals (and to a greater extent "sex-typed" individuals) to take shortcuts in interpreting the information they receive and provide them with prescriptive information about what is considered appropriate for each gender (in the form of stereotypes).

Three differences between the participants from Madrid and Barranquilla can be highlighted. First, we observed, in general, a more intense gender bias among the students in Barranquilla than among those in Madrid. For example, if we look at tables 1 and 2, we see that the difference between the highest male-female ratio (most masculinized recommendation) and the lowest male-female ratio (most feminized recommendation) was 1.50 in the case of Madrid and 2.11 in the case of Barranquilla. Likewise, the gender bias in the attribution of mathematical ability was considerably higher among the Barranquilla participants than among the Madrid ones. Second, in the case of Barranquilla, the gender bias is accompanied by the "differential double standards" phenomenon (penalizing the male target less than the female target for having an academic record that is not high), both for the attribution of mathematical ability and for the recommendation to study computer engineering. And, third, in Barranquilla there are two careers that are recommended with a large male bias (Economics and Business Administration), which are unbiased recommended careers in Madrid. It is possible that these differences have to do with a greater persistence of the traditional social and gender norms in Barranquilla, as compared to Madrid, as well as with the presence of some differential aspects in the content of those traditional social norms.

In line with the fact that, in general, women (on average) tend to have slightly more advanced gender attitudes than men (Bolzendahl and Myers 2004), in the Madrid sample it is noticeable that the bias against the female target in the attribution of mathematical ability only occurred among the male participants and not among the female participants.

Another interesting aspect that we have detected in our research is that, for both the Spanish and Colombian samples of participants, STEM careers (both technological and health sciences) are recommended to a greater degree when the target has a high academic record (and not so much when they have an intermediate one). This result seems to be capturing the idea or stereotype that "to study science or technology you need to be a very good student, to study social sciences, humanities, etc., this is not as important".

Regarding the validity of our research, we consider it has a high degree of internal validity, derived from the controlled experiment (2x2 factorial) that we have run, which has allowed us to make a series of inferences regarding cause-effect relationships. Regarding its external validity, we think there are two reasons why the fact that the participants are university students does not prevent our conclusions from being generalizable to other groups. First, unlike other studies within the field of EVT (where it is essential to work with parents, tutors, children), in our research our intention was specifically to capture possible biases (based on existing stereotypes) in the recommendations offered by any “potential” tutor to a “fictitious” 15-year-old target. For instance, even if we had conducted the experiment with real parents, these, in any case, would have evaluated the profile of the fictitious target and not that of their own children. Second, we consider that gender stereotypes are similar for all social groups, including university students. In any case, and given the characteristics of our participants (adults, young people, with a high cultural level and relatively socially privileged), we consider that the biases detected also hold for other social groups, but, in terms of their intensity, our results constitute the low end of what in reality exists.

We want to draw some implications for public policy from the results of our research. A first step in neutralizing biases based on stereotypes is to be aware that we may be biased. In this research we have shown that gender biases in the attribution of mathematical ability and in the recommendation to study engineering are still very strong. We think it is very important to generate supportive learning environments and conduct awareness campaigns in schools (for example, providing role models of women scientists), all aimed at encouraging girls to pursue mathematics and science. We believe that these campaigns should include parents, teachers and other tutors, who should be alert to the persistence of the bias we have analyzed here.

Second, we believe that in order to change gender stereotypes related to mathematics and technological STEM it is very important to generate appropriate role models. We have seen that our Colombian participants studying engineering came from class groups with uncharacteristically high percentages of women for Colombian standards. And we have observed that precisely for this group of students the bias in favor of the male target in the recommendation to study mechanical engineering did not appear. To generate these supportive role models, we again recommend the awareness campaigns cited in the previous paragraph.

Finally, in order to level the playing field in STEM it is necessary to level the playing field in unpaid work. A world in which it will seem absolutely normal for us to see women in the highest STEM positions will be a world in which it will seem absolutely normal for us to see (for example) men taking leave to care for their baby. Eliminating stereotypes in science means also eliminating stereotypes in the family.

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Appendix.

Subjects and grades that appeared in the academic record included in the brief description of a fictitious 15-year-old student.

Subjects*	**Grades**	
	High	Intermediate
Geography and History:	9	7
Spanish Language and Literature:	9	7
Mathematics:	9	7
English language	9	7
Physical education:	8	6
Ethical values:	10	8
Physics and chemistry:	9	7
Biology:	9	7
Economics:	9	7
Information and communication technologies:	9	7
Music:	8,5	6,5

* These 11 subjects are among those included in the official curricula of compulsory secondary education in Spain and Colombia.