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Models and references that influence gender stereotypes in STEM: a case study in Spain

Modelos y referentes que influyen en los estereotipos de género en STEM: un estudio de caso en España

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Abstract

The science, technology, engineering, and mathematics (STEM) sector is an academic and professional field with high gender disparity figures despite being a field with a low unemployment rate. The "Questionnaire with University Students on STEM Studies in Higher Education" (QSTEMHE) was designed to determine the opinion of the Spanish university population on all branches of knowledge about gender stereotypes in STEM studies. This validated instrument was applied to a university sample of 2101 people from different Spanish universities. A quantitative methodology and the non-experimental ex-post-facto method were used, employing a simple random sampling technique. This study aims to analyse the relationship established between the models and references that university students have had and their manifestation of gender stereotypes on the ability to perform in STEM higher education studies. Among the main results, gender stereotypes about STEM degrees persist, considering them masculinised and male-oriented. Furthermore, the study confirms that models and references taken into account when choosing higher education studies impact the perception of men and women regarding stereotypes in STEM.

Keywords: STEM; higher education; role models; gender stereotypes

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Resumen

El sector de la ciencia, la tecnología, la ingeniería y las matemáticas (STEM) es un ámbito académico y profesional con altas cifras de disparidad de género, a pesar de ser un campo con una baja tasa de desempleo. El cuestionario "Questionnaire with university students on STEM studies in Higher Education" (QSTEMHE) se diseñó para conocer la opinión de la población universitaria española en todas las ramas de conocimiento sobre los estereotipos de género en los estudios STEM. Este instrumento validado se aplicó a una muestra universitaria de 2101 personas de diferentes universidades españolas. Se utilizó la metodología cuantitativa y el método no experimental ex-post-facto, empleando la técnica de muestreo aleatorio simple. Este estudio pretende analizar la relación que se establece entre los modelos y referentes que ha tenido el alumnado universitario y su manifestación de estereotipos de género sobre la capacidad de desempeño en los estudios superiores STEM. Entre los principales resultados, persisten los estereotipos de género sobre las titulaciones STEM, considerándolas masculinizadas y orientadas a los hombres. Además, el estudio confirma que los modelos y referentes tenidos en cuenta a la hora de elegir los estudios superiores inciden en la percepción de hombres y mujeres sobre los estereotipos de STEM.

Palabras clave: STEM; educación superior; modelos; estereotipos de género

Introduction

The received education significantly impacts the construction of gender stereotypes as it has a socialising function (Bourdieu, 1984). In this sense, customs and beliefs are formed under the first socialisation, which is why gender roles, socially ingrained by culture, are reproduced in adulthood (Hernández Méndez, 2013). On the other hand, stereotypes are social representations that materialise in ideas and social practices (Bourdieu, 1984) and are inserted as forms of thought.

Women face a phenomenon known as the Stereotype Threat due to traditional sociocultural stereotypes that white and cisgender men achieve success in STEM disciplines over other profiles (Corbett & Hill, 2015). This threat is documented in women's performance in male-stereotypical occupations and computer science (Diekman et al., 2015; Heybach & Pickup, 2017; Master et al., 2016). Given that the STEM sector has been socially ascribed to men (Berryman, 1983; Blackburn, 2017; Stoeger et al., 2017), women may fear rejection in the field of study and career (Eccles & Wang, 2016; Pomerantz & Eaton, 2001).

Traditional beliefs about what men and women should be like also set expectations about the behaviour expected of men and women (Thébaud & Charles, 2018). Men are expected to be ambitious, while women are socially expected to be kind and approachable. According to Thébaud & Charles (2018), men are culturally assigned high levels of intelligence and agency. Socially, STEM fields, such as physics and computer science, are also considered male-dominated, given the ascribed qualities of talent and success in these areas. These gender biases make girls less likely to feel especially intelligent in STEM doctrines (Bian et al., 2017; Eddy & Brownell, 2016; Gottfried et al., 2017).

In practice, for women to persist and succeed in these fields, such as science and mathematics, it is necessary to reject stereotypes about women in the field to protect their self-concept (Stout et al., 2011). One of the stereotypes they must confront is that they have less mathematical ability to perform in the field (Shapiro & Williams, 2012) and that men are better at mathematics and science than women (Good et al., 2008). Women studying STEM also believe that if they look and behave socially feminine, they may not be sufficiently prepared to engage in science (Banchefsky & Park, 2018). In this way, gender differences lead to the formation and reproduction of shared stereotypes about culturally understood femininity and masculinity (Correll, 2004; Finzel et al., 2018). Girls have to deal with significantly lower self-evaluations than boys due to stereotypes about their STEM competencies, leading them to have lower expectations of STEM qualifications (Correll, 2004).

Finally, according to Dennehy & Dasgupta (2017), many engineering environments are slightly hostile or sometimes overtly hostile to women. The shortage of women, the non-verbal behaviour of men colleagues that excludes women from professional conversations (Barthelemy et al., 2016), and the use of men pronouns to refer to all scientists and engineers without considering the presence of women (Stout et al., 2011), and the prevalence of sexist jokes (Gonsalves et al., 2016), are signals that convey to women that they do not belong in the STEM context (Dennehy & Dasgupta, 2017). Even in organisations that prioritise diversity, there is an implicit assumption that the ideal engineer is male, which undermines women's belonging and self-efficacy and leads to burnout and attrition (Hall et al., 2015).

In this context, a literature review was carried out for Verdugo-Castro, García-Holgado, and Sánchez-Gómez (2022). The main finding of the review was that although there is research on cultural influences (Chan, 2022) and behavioural factors (Tandrayen-Ragoobur & Gokulsing, 2022), none of the identified studies delves into the different possible models, whether family, educational, social, or from films, series, music, video games or other multimedia and audiovisual content formats.

Due to the impact of gender stereotypes on the social attributions to men and women in STEM disciplines, this study aims to analyse the relationship established between the models and references that university students have had at the time of choosing higher education studies and their manifestation of gender stereotypes on the ability to perform in STEM higher education studies. In particular, we answer the following research question "are the gender stereotypes that the university population has about STEM higher education studies related to the models and references that they have had at the time of choosing the higher studies to pursue?". The simple random probability sampling technique was used to achieve the objective and answer the research question, and the "Questionnaire with university students on STEM studies in Higher Education" (QSTEMHE) was applied to a sample of 2101 university students.

Methodology

Participants

Concerning the population and the data collection process, the QSTEMHE questionnaire (Verdugo-Castro et al. 2020; Verdugo-Castro, et al., 2022a, 2022b) is designed to be applied to the university population. Regardless of whether they belong to a public or private university, people of different genders, ages, and branches of knowledge can participate by answering the questionnaire.

Thus, the questionnaire was applied during the last months of the 2020/2021 academic year in different public and private universities in Spain to meet the study's objective. The questionnaire includes questions about the references and models students have had when choosing which higher education studies to pursue (Verdugo-Castro et al. 2020; Verdugo-Castro et al.,2022a, 2022b).

During the academic year 2020/2021, the number of students enrolled in public or private universities in Spain was 1,336,009 people in Bachelor's studies (56.08% women and 43.92% men), 247,251 in Master's studies (55.32% women and 44.68% men), and 95,797 in Doctoral studies (50.09% women and 49.91% men) (EDUCAbase, 2022).

Non-probabilistic quota sampling was used for data collection in the study. Random methods were not employed in the data collection process. Participants were selected based on specific characteristics, which served as the quotas. These characteristics included gender and branches of knowledge, aiming to achieve diversity in genders and branches of knowledge. Representativeness by branches of knowledge and gender at the national level was considered to achieve a representative sample.

After the implementation of the survey, 2101 valid responses were finally collected. Thus, the study's final sample is 2101 people (65.30% women, 33.22% men, and 0.76% non-binary gender). Concerning the branch of knowledge, 30.18% belong to the Social and Legal Sciences branch, 22.18% to Engineering and Architecture, 18.99% to Sciences, 17.51% to Health Sciences, and 11.14% to Arts and Humanities. Therefore, 41.17% belong to STEM studies and 58.83% to non-STEM studies. Thus, of the 98.52% of the sample who identified as either female or male, 20.80% (437) were STEM women, 44.50% (935) were non-STEM women, 19.61% (412) were STEM men, and 13.61% (286) were non-STEM men. On the other hand, 65.40% are studying Bachelor's or Double University Degrees, 10.04% are studying Master's Degrees, and 24.56% are studying PhDs.

Instruments

For the presented study, the empirically validated instrument "Questionnaire with university students on STEM studies in Higher Education (QSTEMHE)" (Verdugo-Castro et al. 2020; Verdugo-Castro(Verdugo-Castro et al. 2020; Verdugo-Castro et al.,2022a, 2022b) was used and applied. According to the authors Verdugo-Castro et al. (2022b), the QSTEMHE questionnaire is constructed to be able to study the gender biases and stereotypes that are produced and manifested about the ability to perform in STEM areas as a function of the individual's gender. In other words, the QSTEMHE questionnaire is designed to identify gender biases in STEM studies. As for the target population, according to the authors Verdugo-Castro et al. (2022a), the instrument is prepared to be applied to a university population in any branch of knowledge. Moreover, the instrument can be applied in both English and Spanish since the questionnaire is published in both languages. The questionnaire was applied in Spanish for this study since the research was carried out with a Spanish university population.

The validated version of the QSTEMHE instrument has five dimensions and twenty-four items. The dimensions are interests (D1_INT), perception and self-perception

(D2_PAP), gender ideology (D3_IG), attitudes (D4_AC), and expectations about science (D5_EXC).

Gender Ideology (D3_IG) is related to the social conception of gender roles and patterns. The understanding of the conceptualisation of Gender Ideology has been approached from the perspectives of gender ideology of Banchefsky & Park (2018), who address four possible positions in their study: Gender Awareness, Gender Blindness, Segregationism, and Assimilationism. The authors identify two negative gender positions as they move away from gender equality: Assimilationism and Segregationism. On the other hand, the authors identify two positive gender positions as they approach gender equality: Gender Awareness and Gender Blindness.

On the other hand, in terms of Perception and Self-Perception (D2_PAP), misperceptions about careers in STEM domains significantly impede women's ability to pursue careers in STEM (Diekman et al., 2010). In turn, self-perception may also lead to low rates of showing interest and enrolment or continuation on the pathway.

Regarding Science Expectations (D5_EXC), these have to do with the results that are expected from it, as well as from the study of it. Outcome expectations are beliefs about the effects of specific activities (Lent et al., 1994), in this case, about studying STEM domains or not. Furthermore, Attitudes towards science (D4_AC), according to Osborne et al. (2003), can be understood as the feelings, beliefs, and values that a person has about an object, which can be, in this case, science, science at school, the impact science has on society, the science-based labour market, including scientists themselves.

Finally, regarding Interest (D1_INT), studies like Blázquez et al. (2011) investigated the inclination of Spanish students towards pursuing engineering in higher education. Results indicate that 30% of participants in the pilot study aren't of the appropriate age for higher education, suggesting some may choose studies without proper qualifications. Hence, education systems strive to foster interest in STEM fields. Nevertheless, students' interest is waning, leading to enrollment declines. Blickenstaff (2005) and Sadler et al. (2012) highlight gender disparities, with women leaning towards health and social sciences and men towards technical and exact sciences.

The reliability indicator of Cronbach's Alpha for each of the five dimensions is presented in Table 1, following their empirical validation.

Table 1

Cronbach's Alpha reliability indicator for the five dimensions of the QSTEMHE questionnaire. Source: Own elaboration.

Dimension	**Reliability (Cronbach's alpha)**
D1_INT	0,741
D2_PAP	0,746
D3_IG	0,726
D4_AC	0,645
D5_EXC	0,761

Also, Table 2 shows the relationship between the five dimensions and their component items.

Table 2

QSTEMHE instrument: dimensions and items. Source: Verdugo-Castro et al. (2022a, 2022b).

Dimensions	Items
D3_IG (7)	· D3_33_I. University studies are more important for men than for women. · D3_37_I. In the IT field, a man's performance will be better than a woman's. · D3_38_D. Women are capable of developing useful software. · D3_45_I. Girls are not as good as boys in STEM issues. · D3_47_I. STEM themes are more masculine than others. · D3_48_I. Girls have fewer natural abilities than men for STEM issues. · D3_49_I. Most girls are better at other things (such as letters/languages) and choose studies in which they are better.
D4_AC (5)	· D4_26_I. If a woman decides to enter a traditionally masculine field, she will be more successful if she adopts the prevailing male customs and behaviours. · D4_28_I. Having men and women work side-by-side increases the likelihood of conflict. · D4_34_I. Women must sacrifice their careers to support their children/family. · D4_43_I. Women working in STEM areas have to be/act like men. · D4_44_I. To have a successful career in STEM you need to think and act like a man.
D1_INT (5)	· D1_39_I. At home, boys do more practical activities with their parents than girls (e.g. cars, tools, computers, etc.) · D1_41_I. Boys prefer STEM-related hobbies. · D1_42_I. There are more boys than girls in STEM studies as they are more freaks. · D1_46_I. Girls are not as interested as boys in STEM issues. · D1_51_I. University studies in STEM are generally more attractive to boys.
D2_PAP (4)	· D2_52_I. I feel restricted by the gender labels that people attach to me. · D2_53_I. I feel restricted by the expectations that people have of me because of my gender. · D2_54_I. In my childhood home, I was taught that men should act like men and women should act like women. · D2_56_I. In the past, I have been teased or bullied for acting like the opposite sex.
D5_EXC (3)	· D5_59_D. Science is helpful in my everyday life. · D5_60_D. Learning science has made me more critical in general. · D5_61_D. Science and technologies will provide greater opportunities for future generations.

Procedure

The study focused on the relationship established between the models and references (nuclear family, extended family, peer group, teachers, prestigious characters, characters from audiovisual environments and video games, etc.) that university students have had at the time of choosing the higher education studies to pursue and their manifestation of gender biases regarding STEM higher education studies.

A quantitative methodological design was followed using the non-experimental ex-post-facto method (Hernández Sampieri et al., 2014) to achieve the objective of analysing the relationship established between the models and references that university students have had at the time of choosing higher education studies (explanatory variables) and their manifestation of gender stereotypes on the ability to perform in STEM higher education studies (criterion variables). The role models and references are considered positive influences, given that a priori, they have satisfactorily promoted their choice of which higher education studies to pursue.

Regarding the distribution of the questionnaire, it was shared online using the survey application LimeSurvey. The questionnaire was disseminated among the Spanish university population through institutional emails during 2021. The data obtained were stored according to the research ethics rules and guidelines of the University of Salamanca. The study obtained a favourable report to guarantee the ethical principles of the research. The registration number provided by the University of Salamanca Ethics Committee is 557.

Regarding gender, the study was designed so that people of different genders could participate. However, more than 98% of the final sample only consisted of men and women. People of non-binary gender represented only 0.8%. Thus, it was impossible to collect a sufficiently representative sample of this population segment to apply hypothesis tests to them. The hypothesis tests are therefore carried out with men and women.

On the other hand, as previously mentioned, the QSTEMHE instrument can be applied to any branch of knowledge. This is why the Spanish university population of all branches of knowledge was considered for this study.

Thus, the study's contrasting hypotheses (H_0 and H_1) are shown in Table 3.

Table 3

Hypothesis of the study.

Sample		Hypothesis
Women in STEM studies	**H_0**	STEM women's opinion of STEM studies to gender is not related to having had role models/referents and what these have been
	H_1	STEM women's opinion of STEM studies to gender is related to having had role models/referents and what these have been

Women in non-STEM studies	$\mathbf{H_0}$	Non-STEM women's views on STEM higher education to gender are not related to having had role models/referents and what these have been
	$\mathbf{H_1}$	Non-STEM women's views on STEM higher education to gender are related to having had role models/referents and what these have been
Men in STEM studies	$\mathbf{H_0}$	STEM men's views on STEM higher education to gender are not related to whether they have had role models/referents and what these have been
	$\mathbf{H_1}$	STEM men's views on STEM higher education to gender are related to whether they have had role models/referents and what these have been
Men in non-STEM studies	$\mathbf{H_0}$	Non-STEM men's views on STEM higher education to gender are not related to having had role models/referents and what these have been
	$\mathbf{H_1}$	Non-STEM men's views on STEM higher education to gender are related to having had role models/referents and what these have been

Data Analysis

The data was analysed using inferential statistics and two analysis software packages, SPSS v.25 and JASP. Firstly, the descriptive statistics of the variables were extracted. Secondly, the Shapiro-Wilk normality test was applied. For the different contrasts that have been made between gender (men and women), belonging or not to STEM studies, and the possible referents for each criterion variable, normality has not been obtained; therefore, thirdly, non-parametric tests have been applied. The non-parametric Mann-Whitney U test was used because the tests are for two independent samples. The two independent samples are "having had a certain model as a referent" and "not having had this same model as a referent".

In this way, four groups were formed for comparison based on two of the study's sociodemographic variables, which are gender and belonging to STEM or non-STEM studies. Thus, four groups have been formed: women belonging to STEM studies, women belonging to non-STEM studies, men belonging to STEM studies, and men belonging to non-STEM studies.

These group divisions have allowed analysis of how different models or references influence gender stereotypes regarding STEM higher education, concerning being a STEM women, non-STEM women, STEM men, or non-STEM men.

Results

This section of the article is divided into nine sections. Each section presents the results obtained for the referent(s) analysed. The results are presented for those referents in which significant differences in value have been detected and which allow us to answer the hypotheses and research questions. Thus, all of them are presented, except for a youth association member, due to the limited findings of significant differences.

Concerning the results tables, the study's authors would like to point out that the complete set of tables with the results is shared in the only appendix associated with this article. The article's only appendix comprises two sheets. The first sheet is titled Results-Contrasts, while the second is titled Results-Descriptive statistics.

On the first sheet (Results-Contrasts), tables containing the results of the hypothesis tests are compiled, specifically for those where significant differences were detected for the sample. These tables include the value of the statistic, the p-value, and the effect size. Tables for contrasts with no significant differences have been omitted to facilitate the appendix reading. In this sheet (Results-Contrasts), each model or reference is assigned a numerical value to organise the results tables. For instance, A.1 represents "mother," A.2 represents "sister," and so forth, up to A.11, corresponding to having no model or reference when choosing higher education studies.

On the other hand, the second sheet of the appendix (Results-Descriptive statistics) provides the frequencies of the compared groups, along with the means and medians obtained for the two compared groups, specifically for those items where significant differences were found. Like the previous sheet, in the second one (Results-Descriptive statistics), the tables follow a specific order, organised in columns. Each column corresponds to a reference, and each table has its enumeration. For instance, B.1 is the code corresponding to "mother," B.2 is the code for "sister," and so on up to B.11.

Moreover, the descriptive statistics for the scale items are presented in Table 4. The letter D in the items symbolises that the item is worded in the direct sense, while the letter I means that the item is worded in the reverse sense. Also, there were four response options, with 1 meaning totally disagree and 4 meaning totally agree.

Table 4

Descriptive statistics for the Likert scale items.

Item	N	Mean	SD
D4_26_I	1926	2.045	0.892
D4_28_I	2062	1.366	0.611
D3_33_I	2036	1.157	0.440
D4_34_I	2058	1.412	0.798
D3_37_I	2052	1.181	0.492
D3_38_D	2065	3.884	0.450

D1_39_I	1822	2.198	0.942
D1_41_I	1831	1.955	0.838
D1_42_I	1938	1.817	0.857
D4_43_I	2071	1.247	0.531
D4_44_I	2070	1.221	0.523
D3_45_I	2076	1.242	0.696
D1_46_I	2015	1.732	0.893
D3_47_I	2047	1.411	0.709
D3_48_I	2063	1.186	0.466
D3_49_I	1993	1.520	0.733
D1_51_I	1961	2.337	0.945
D2_52_I	2033	2.091	1.083
D2_53_I	2052	2.098	1.091
D2_54_I	2062	1.780	0.972
D2_56_I	2043	1.729	0.968
D5_59_D	2069	3.651	0.576
D5_60_D	1985	3.458	0.717
D5_61_D	2036	3.641	0.610

Secondly, Table 5 presents the frequencies for each referent analysed in the research, depending on whether they had that referent or not. There were two response options: a value of 1 meant yes, and a value of 2 meant no.

Table 5

Frequencies of the referents analysed.

Referent	N	Mean	SD
Mother	2101	1.772	0.419
Father	2101	1.803	0.398
Sister	2101	1.935	0.246
Brother	2101	1.961	0.193
Other men relatives	2101	1.902	0.297

Other women relatives	2101	1.908	0.289
Men teachers	2101	1.800	0.400
Women teachers	2101	1.791	0.407
Men friends	2101	1.932	0.251
Women friends	2101	1.930	0.256
Member of a youth association	2101	1.975	0.155
Prestigious men figures in the discipline	2101	1.921	0.271
Prestigious women figures in the discipline	2101	1.929	0.257
Men characters in audiovisual content and video games	2101	1.964	0.187
Women characters in audiovisual content and video games	2101	1.954	0.210
Not having had a role model or reference	2101	1.627	0.484

Mother

Hypothesis tests were conducted to determine whether having a mother as a reference when choosing higher education was related to gender-stereotypical thinking about STEM higher education. The results of the STEM women, non-STEM women, STEM men, and non-STEM men groups were compared to answer the hypotheses stated. The non-parametric Mann-Whitney U test for two independent groups was used for the tests. As mentioned above, only the responses of women and men were considered because the number of responses from non-binary persons is insufficient for comparison.

For the women STEM group, significant differences in item D2_54_I were detected for the sample. On the other hand, for non-STEM women, significant differences were detected for items D2_54_I and D5_60_D.

Their mother has been a role model for 14.94% of women and 7.52% of men. STEM women with their mother as role model are less likely to have preconceived ideas. Non-STEM women with their mother as role model are also less inclined to stereotypical thinking. On the other hand, no significant differences between STEM and non-STEM men were found in their opinions about STEM higher education to gender, depending on whether they had their mother as a role model.

Sister

As with the mother referent, hypothesis tests were conducted with the sister referent. The results of the four groups addressed in the study were compared to answer the hypotheses set out. For the tests, the non-parametric Mann-Whitney U test was used for two independent groups.

For the STEM group of women, significant differences were detected for the sample in items D1_39_I and D4_26_I. For the non-STEM women group, significant differences were detected for item D5_60_D. Significant differences were detected for STEM men in items D1_39_I, D1_46_I, and D1_51_I. Finally, for non-STEM men, significant differences were found in item D3_33_I.

This is also the case when STEM women have their sister as a referent (4% of women and 2.43% of men), as they do not reveal the presence of biased ideas. They reject the idea that if a woman enters a traditionally male field, she will be more successful if she adopts the predominant male customs and behaviours (D4_26_I). For the Attitudes dimension, their mean is low, which is a favourable result.

These results are replicated in non-STEM women who are modelled on their sisters. Their predisposition to think in a biased way is reduced, and they praise the usefulness and importance of science. The same is true for STEM men who model themselves on their sisters. They move away from stereotypical ideas such as that girls are not as interested as boys in STEM subjects (variable D1_46_I) or that boys tend to do more practical things with their parents at home than girls (item D1_39_I).

However, non-STEM men with this referent are slightly more likely than non-STEM men to think that university studies are more important for men than women (item D3_33_I).

Father

Following the steps indicated in the previous sections, the non-parametric Mann-Whitney U test for two independent groups was used for the father figure.

For the non-STEM group of women, significant differences were found for items D3_48_I and D4_43_I. Significant differences were detected in items D2_53_I and D3_48_I for the STEM men group. Finally, significant differences were detected in items D3_33_I and D4_34_I for the non-STEM group of men.

Furthermore, for 11.81% of women and 7.71% of men, their reference point was their father. Non-STEM women with their fathers as a reference point are more likely to have a biased opinion. Subtly, their opinion is closer to preconceived thinking than those without their father as a reference point. For example, they have higher mean values for the idea that women working in STEM must be and act like men (item D4_43_I) and that girls have fewer natural abilities than men in STEM subjects (item D3_48_I).

Also, STEM and non-STEM men who have had their father as a role model are more likely to think that girls have less natural abilities than men in science, technology, engineering, and mathematics (item D3_48_I) or that women have to sacrifice their career to support the family (item D4_34_I). They are also more self-confident, feeling less constrained by people's expectations of them because of their gender (item D2_53_I).

Brother

Some significant differences were detected in the hypothesis tests applied to find out whether having a brother as a reference when choosing higher education was related to gender-stereotypical thinking about STEM higher education. In the group of STEM women, differences were detected in item D3_49_I. For the non-STEM women group, differences were detected in items D4_34_I and D5_60_D. For the STEM group of men they were detected in item D3_47_I. Finally, for the non-STEM group of men they have been detected in item D2_53_I.

In addition, Figure 1 shows the means for the referent father, brother, and other men relatives on the different items for the STEM group of men.

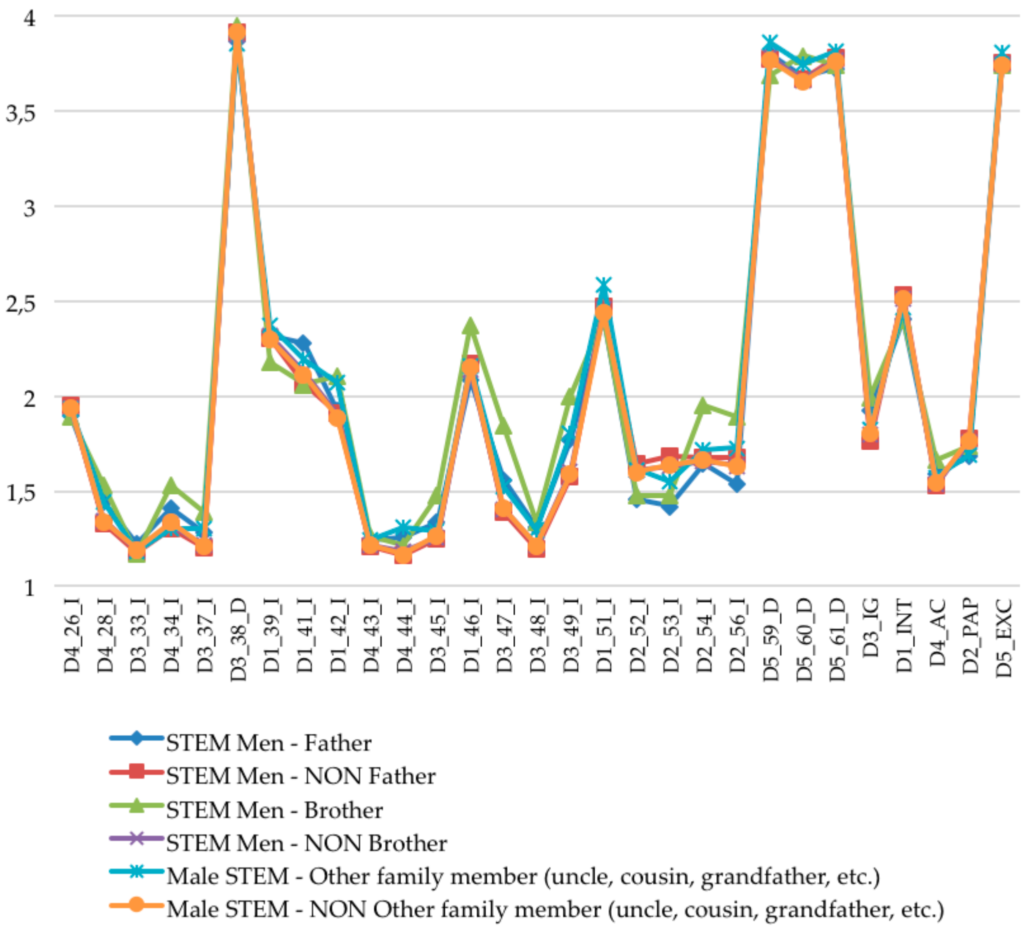

Figure 1. Representation of the means for the variables for the STEM men group: father, brother, and other men family members.

It is striking that those STEM women who have had their brother as a reference (2.10% of women and 1.67% of men) are more prone to gender-biased ideas. For example, these women are more likely to think that most girls are better in fields other than STEM, such as the arts (item D3_49_I). Also, non-STEM women with their brothers as role models are more likely to think that women should sacrifice their careers to support the family (item D4_34_I).

Along these lines, STEM men who have had their brother as a role model are also more likely to think in a biased way than those who have not had their brother as a role model.

Finally, non-STEM men who have had this model feel less constrained by people's expectations of them because of their gender (item D2_53_I).

Other men's and women's relatives

For the other man's relative referent, significant differences have been detected in items D3_33_I and D5_61_D for the STEM women group. Significant differences were detected in items D2_54_I and D3_48_I for the non-STEM women group. For the STEM men group, significant differences were detected in item D4_44_I.

For the other woman relative referent, significant differences were detected in item D3_49_I for the STEM women group and in items D1_46_I, D2_54_I, D3_47_I, and D4_44_I for the non-STEM women group. For the STEM group of men, they have been detected in items D1_39_I, D1_51_I, and D3_48_I. Finally, for the non-STEM group of men they have been detected in item D1_46_I.

5.29% of women and 4.43% of men had a man relative in the extended family as a role model, and 6.43% of women and 2.67% of men had a woman relative in the extended family as a role model. While STEM women show a greater predisposition to stereotypical thoughts if they have a man relative as a role model, they are less predisposed if the role model has been a woman relative. In the first case, they think to a greater extent than STEM women who have not had a man relative as a role model, that tertiary studies are more important for men (item D3_33_I). However, in the second case, they reject that girls are better in other non-STEM disciplines (item D3_49_I).

Regarding non-STEM women, those with a man relative as a role model are more likely to think that girls have fewer natural abilities than men in STEM subjects (item D3_48_I) than non-STEM girls without a man role model. However, as was the case for STEM women, non-STEM women with a woman role model are less likely to be biased in their opinions. They completely reject the idea that you have to think and act like a man to have a successful career in STEM (item D4_44_I), the idea that girls are not as interested in STEM subjects as boys (item D1_46_I), and the idea that STEM subjects are more masculine than others (item D3_47_I).

On the other hand, STEM men with a man relative as a role model are more likely to think that girls have fewer natural abilities than men in STEM subjects (item D4_44_I). However, as in the previous cases, STEM and non-STEM men who have had a woman relative as a role model reject stereotypical ideas, such as girls having less natural abilities than men for STEM subjects (item D3_48_I).

Teachers

Hypothesis tests have also been applied for male and female teachers. Table 6 shows some of the results, and in bold are those where the p-value is less than 0.05; therefore, a significant difference is detected. It is recalled that the full set of results tables can be consulted at the only appendix associated with this article.

Table 6

Results for the model: women teachers.

ID		Women teachers			
		STEM women		STEM men	
		W	p	W	p
D1_INT	D1_39_I	14.603.000	0.993	7.587.000	0.252
	D1_41_I	12.851.000	0.842	8.422.500	0.284
	D1_42_I	16.957.000	0.324	9.554.000	0.139
	D1_46_I	16.265.000	0.411	8.224.500	0.002
	D1_51_I	15.407.000	0.42	9.055.000	0.011
D2_PAP	D2_52_I	20.416.000	0.003	11.440.000	0.628
	D2_53_I	19.859.500	0.02	10.363.500	0.27
	D2_54_I	17.573.500	0.894	10.892.500	0.268
	D2_56_I	17.662.000	0.263	12.987.500	0.079
D3_IG	D3_33_I	17.623.000	0.273	10.006.000	0.006
	D3_37_I	17.081.000	0.537	10.517.500	0.056
	D3_38_D	17.035.500	0.446	13.029.000	0.041
	D3_45_I	16.984.000	0.185	11.408.000	0.203
	D3_47_I	15.927.500	0.152	10.179.000	0.064
	D3_48_I	17.731.000	0.897	11.464.000	0.419
	D3_49_I	17.133.000	0.492	10.323.000	0.494
D4_AC	D4_26_I	18.678.500	0.006	8.077.500	0.031
	D4_28_I	17.877.500	0.575	10.958.000	0.705
	D4_34_I	18.230.500	0.449	11.625.000	0.908
	D4_43_I	18.123.000	0.465	11.457.500	0.487
	D4_44_I	18.201.000	0.362	11.613.000	0.406
D5_EXC	D5_59_D	19.071.500	0.025	14.087.500	0.007
	D5_60_D	18.446.000	0.204	13.846.500	0.027
	D5_61_D	17.787.000	0.454	12.782.500	0.317

Also, reviewing the significant differences detected in having a male teacher as a reference, significant differences were detected in items D4_34_I and D5_59_D for the group of STEM women, in items D1_51_I, D3_33_I, and D4_28_I for the non-STEM female group, in items D1_46_I, D3_47_I and D5_59_D for the STEM male group, and in item D4_34_I for the non-STEM male group. For the referent of a female teacher, significant differences were detected in items D2_52_I, D2_53_I, D4_26_I, and D5_59_D for the female STEM group, in items D3_49_I and D5_59_D for the non-STEM female group, in items D1_46_I, D1_51_I, D3_33_I, D3_38_D, D4_26_I, D5_59_D and D5_60_D for the STEM male group, and in item D3_47_I for the non-STEM male group.

The role of the teacher is known to be crucial in modelling (Kang et al., 2019). 14.43% of women and 6% of men have had a female teacher as a role model, and 10.67% of women and 9.05% of men have had a male teacher as a role model. For STEM women who have had a male teacher as a role model, their opinions are more unbiased, to the extent that they reject the idea that women should sacrifice their careers to take care of their families (item D4_34_I).

However, the results are less favourable if the referent is a female teacher. They are more likely to think that if a woman enters a traditionally male field, she will be more successful by adopting male customs and behaviours (D4_26_I). It is striking that this is true for STEM women with women professors who teach in the STEM sphere, as it raises the question of whether the work dynamics that occur generate the false belief of having to adapt one's behaviour to that of a man to enter and be promoted in these professions (Banchefsky & Park, 2018; Shapiro & Williams, 2012; Stout et al., 2011).

As for STEM women, non-STEM women who are modelled on female teachers also perform worse. They are more likely to consider that girls are better at things other than STEM, such as letters (item D3_49_I).

As for non-STEM women, while having a male teacher as a role model leads them to reject the idea that men and women working side by side increase the likelihood of conflict (item D4_28_I), they are more likely to think that STEM tertiary studies are more attractive to boys (item D1_51_I).

On the other hand, STEM men who have had a male teacher as a role model are also less likely to think in a stereotypical way than those who have not had a male teacher as a role model. This is shared by STEM and non-STEM men who have had a female teacher as a role model. In this case, they reject ideas such as tertiary studies being more important for men than women (item D3_33_I). In addition, they praise the importance and usefulness of science in everyday life (dimension Science Expectations, D5_EXC).

In contrast, non-STEM men with a male teacher as a role model are likelier than non-STEM men to think that women should sacrifice their careers to support their children/family (item D4_34_I).

The peer group

For the referent of a man friend, significant differences were detected in items D1_39_I and D4_34_I for the STEM women group, in items D1_39_I, D2_54_I, and D4_26_I for the non-STEM women group, and in items D4_44_I, D5_59_D, D5_60_D and D5_61_D for the non-STEM men group.

For the woman friend referent, significant differences were detected in items D1_46_I and D4_34_I for the STEM women group, and items D1_39_I, D4_26_I, and D5_61_D for the non-STEM women group.

Regarding having a man friend as a reference (2.86% of women and 3.71% of men), STEM women who considered this were less inclined to stereotypical thoughts. These STEM women reject the idea that women should put family before work (item D4_34_I). This conclusion is significant because it is necessary to break the pre-set moulds and start not to give women a choice between their professional future and their development as a mother.

In addition, non-STEM women who have had a man friend as a reference also show results far from stereotypes, rejecting social constructs such as item D2_54_I: In my house, I was taught that men should act like men and women should act like women.

STEM and non-STEM women with a woman friend as a reference (5.23% of women and 1.62% of men) also showed a low likelihood of the stereotypical opinion. Again, they rejected the idea that women should put family before work (item D4_34_I). Another idea they rejected is that if a woman decides to go into STEM, she will be more successful if she adopts the predominant male customs and behaviour (D4_26_I).

However, non-STEM men with a man friend as a role model were slightly more likely to hold stereotypical views than non-STEM men who did not have such a role model.

Prestigious figures in the discipline

Not all role models have to be family members or peers. People who work in the field and have sufficient prestige to be recognised can also be role models. 2.90% of women and 4.81% of men felt that their point of reference was a man recognised in their discipline, and 4.47% of women and 2.43% of men felt that their point of reference was a woman recognised in their field. Men have more men referents than women, although women have more women referents than men.

For a man character, significant differences have been detected in item D1_39_I for the group of STEM women. For the non-STEM women group, significant differences were detected in item D2_53_I. For the men STEM group, they were detected in items D4_44_I, D5_59_D, and D5_60_D. Meanwhile, significant differences have been detected in items D3_45_I, D3_47_I, and D5_60_D for the group of non-STEM men. On the other hand, if the referent is a woman character, significant differences were detected in item D3_47_I for the group of non-STEM women and in item D5_59_D for the STEM men.

STEM women with a man character as a role model are more likely to think that boys do more practical things with their fathers at home than girls (item D1_39_I). Therefore, it would be necessary to review what kind of content and direct and indirect discourse these characters provide to motivate them to think in this way.

However, non-STEM women with a woman character as a role model were less likely to think that STEM subjects are more masculine than others (item D3_47_I).

On the other hand, STEM men who have had a man or woman role model are more likely to value the usefulness of Science. However, STEM and non-STEM men with a man role model are more likely to think that to have a successful career in STEM is necessary to think and act like a man (item D4_44_I) or that girls are not as good as boys in STEM subjects (item D3_45_I).

Characters in audiovisual content and video games

Finally, hypothesis tests were applied for other references: characters from films, series, comics, music, videogames, etc. For the men referents, significant differences were detected in items D3_47_I and D3_49_I for the group of STEM women, and in items D4_26_I and D5_60_D for the group of STEM men. For the women referents, significant differences were detected in items D2_52_I, D2_53_I, and D2_56_I for the STEM women group, and in items D3_47_I and D3_48_I for the non-STEM women group.

3.24% of the women and 1.24% of the men in the study considered a woman character as their role model and 1.57% of the women and 1.95% of the men considered a man character as their role model. As in the previous case, men tend to consider other men as referents to a greater extent than women, and vice versa. Ultimately, all the people considered idols by young people will likely be referenced for them. That is why taking care of the discourse and the message they send out is so elementary.

STEM women with a man role model as a reference are more prone to stereotypical thinking, for example, that STEM subjects are more masculine than others (item D3_47_I). This finding makes us reflect on what image is presented in audiovisual content about scientists, technologists, mathematicians, and engineers (Kaye et al., 2017).

However, this is also the case for STEM women who take a woman's character as a role model. In this case, they feel constrained by gender labels (item D2_52_I) and expectations about their gender (item D2_53_I) and report being teased or bullied for acting as the opposite sex (item D2_56_I). It is striking that STEM women feel so conditioned by what is expected of them, as if doing science, technology, mathematics, or construction could not also be expected of them.

As for non-STEM women with a woman character as a role model are less likely to think that girls have less natural abilities than men in STEM subjects (item D3_48_I).

Lastly, STEM men who had a man character from audiovisual content and video games as a role model obtained better results than STEM men who did not have such a role model. On the other hand, no significant differences were detected for STEM and non-STEM men with a woman character from audiovisual content and video games as role model.

Finally, as can be seen from the various hypothesis tests carried out and presented, the four null hypotheses discussed are rejected, given that significant differences have been detected in the sample for the different non-parametric tests used.

Thus, in answering the paper's research question, the answer is clear: Yes, university students' gender stereotypes about STEM higher education are related to their educational references. This will be discussed in more detail in the discussion of the paper.

Discussion

The study is based on the QSTEMHE questionnaire, which is presented throughout the article. This instrument was applied to the Spanish university population in 2021 to determine whether the references they had had when choosing their higher education studies were related to the possible existence of stereotypical gender thinking in STEM disciplines. Given the findings obtained, the null hypotheses were rejected. It was confirmed that the referents are related to the modulation of stereotypical thinking for STEM and non-STEM women and for STEM and non-STEM men.

Based on the results obtained, it is not a matter of making vague reductionisms by making a simple differentiation between women and men referents (Heybach & Pickup, 2017).

Social, cultural, academic, economic, and professional systems are segregated (Lent et al., 1994). This system problem concerns, of course, the men and women who decide to pursue higher education (Berryman, 1983; Lent et al., 1994), but also their families (Diekman et al., 2015), their faculty (Kang et al., 2019), their peer group (Gottfried et al., 2017), including other people around the students.

Along the line of referents comes into play modelling (Finzel et al., 2018; Heybach & Pickup, 2017), who young people take into account when deciding and how these people somehow modulate their opinion.

In the family environment, it can be seen that mothers and sisters are good role models, given that those who have had them as role models are less predisposed to stereotypes. However, fathers and siblings are more associated with the presence of opinions more prone to bias. As has been consulted in the literature, in some cases from these figures, a paternalism is produced in which the idea of "wanting to help", "wanting to make it easier", and "wanting to support" is expressed, assuming that perhaps it is necessary to help, facilitate, support, especially women (Eccles & Wang, 2016; Pomerantz & Eaton, 2001). Although bad intentions do not usually accompany these behaviours, they can indeed undermine self-confidence and self-concept, especially in the case of girls (Pomerantz & Eaton, 2001). Therefore, it is essential to highlight the person's potential and abilities and not fall into the error of thinking that they cannot do it alone. However, it is striking that men who have their fathers and brothers as role models feel less constrained by social expectations about their gender as if the father figure provides this security.

As for other extended family members, it is striking that, along the same lines as above, both men and women with a woman role model are less likely to think in a biased way than if their role model is a man.

The positive side of these findings is that women are good role models for both men and women in the STEM environment and beyond (Heybach & Pickup, 2017). It is, therefore, interesting to take these role models as role models. The worrying side is why familiar men figures do not impact both genders equally. The results reveal differences that suggest that the contributions of the literature are confirmed when it is commented that paternalism leads to a loss of self-concept and self-confidence (Pomerantz & Eaton, 2001).

However, the results change substantially when the analysis is carried out for teachers. Women and men who have had a male teacher as a reference are more unbiased. This is only not true for non-STEM men who think that women have to sacrifice their careers to provide for their children/families to a greater extent. On the other hand, men who have had a female teacher as a role model also have a lower presence of stereotypical ideas. However, if women have had a woman as a role model, they are more likely to think in a biased way.

The literature addresses the problem that exists in the field of women teachers (Stout et al., 2011). Due to the pressure exerted on them by gender or the work environment, some have to work doubly hard to be recognised and valued, which leads to lower self-efficacy, especially in STEM fields (Eddy & Brownell, 2016).

In addition to taking care of teacher self-efficacy and the way it is transmitted to students, other elements should be taken care of, as the literature points out, such as the way teachers express themselves to students, the content of textbooks themselves, and positive reinforcement should be strengthened (Kang et al., 2019).

On the other hand, the peer group is also influential (Gottfried et al., 2017). While the influence of men friends is often positive for women, it is less so for non-STEM men. However, the influence of women friends is positive for both STEM and non-STEM women. Logically, the peer group functions as a mirror; this will also be transmitted if friends are not prone to stereotype. It is also good to see how members of youth associations can have a positive impact.

As for other role models, care must be taken with the transmitted content and how it is transmitted (Stoeger et al., 2017). When discussing prestigious role models, having a woman role model is more favourable for women than having a man role model. This is also the case for men, STEM, and non-STEM, who have had a man role model, as they obtain less favourable results.

Concerning the references linked to audiovisual content and video games, it is striking that STEM women who have had a man reference point are more prone to biased thinking, and those who have had a woman reference point feel more limited by gender labels and expectations. This begs the question: do films and series portray men and women in these fields equally, do science-related video games portray women in a non-sexist way, do the media portray women leaders in the field of science in the same way as men leaders, and do the media portray women leaders in the field of science in the same way as men leaders? Fortunately, progress has been made in answering these questions, and men and women are beginning to be presented equally. However, it is only the beginning of an arduous, intense, and long trajectory of struggle, where white, cis, and heteronormative men have been linked with leadership, with the mandate, with science, and women have been assigned roles as assistants, companions, but not counterparts (Blackburn, 2017).

The main limitation encountered in the study was the slowing down of the study. Because of the COVID-19 pandemic, it was considered safer to disseminate the instrument online, which required numerous contacts and reminders. Another limitation found in the study is that, although the sample size was 2101 people, which constitutes a large sample size, the comparison groups, in some cases, have been smaller in sample size. The reduced sample size for some comparison groups means that while the applied instrument reports reliability indices and the sample size ensures the representativeness of population quotas, it would have been interesting to have balanced groups with a high sample size for all contrasts. Nevertheless, the responses obtained regarding the references considered when choosing higher education studies reflect the reality of the university, which is studied in this article. As for the future, based on the findings, the aim is to establish lines of work based on co-education and the demystification of STEM professions.

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