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Static and dynamic assessment of STEM gender stereotypes in secondary education using a novel cluster-based analysis

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Abstract

Gender stereotypes are still present in the career choice. Students make decisions about future profession based on a stereotyped perception of studies. The under-representation of women in the field of science, technology, engineering and mathematics, can be explained by this gender gap in the career choice. This article explores the influence of gender stereotypes in the career choice of high school students and presents two aims: first, to analyze perceived stereotypes that boys and girls have towards studies and degrees; and second, to test the time evolution of these gender stereotypes. Statistical analysis was carried out to identify gender stereotypes, and cluster-based analysis to link stereotypes to cluster prototypes and identify hidden groups of behavior. A survey was used to collect data on gender stereotypes. The sample comprised 1844 students from Valencian Community high schools. According to previous studies, our results show that gender stereotypes showed influence on students' perception of professions. Boys have more stereotypes than girls, and this difference is even higher among students who intend to study engineering. Regarding to time evolution, an increase of gender stereotypes among students is detected, especially between girls and students who do not intend to study engineering. The conclusion determines the relationship between traditional gender roles and present professions. Students believe that there are more suitable careers for men or women: technology and engineering for men, education and psychology for women. In addition, these gender stereotypes have increased in the last 10 years. Therefore, the impact of gender stereotypes on career choice may have also increased.

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Introduction

Nowadays, the differences between women and men in the career choice and in the occupational distribution are still a real fact. These gender differences have been reduced in the last decades because of legislative measures and actions implemented by universities, schools and educational organizations, as well as by general changes in society. However, the gender gap in career choice is still very remarkable.

The differences between girls and boys begin to appear in the High School choice of subjects (Han, 2016; López-Sáez et al., 2011). This choice inevitably determines the selection of subsequent university studies and their professional career (Chan et al., 2019; Colette & Marjolaine, 2017; Liu & Chiang, 2020). Girls continue to choose mainly careers in health sciences and social sciences, while boys opt more for studies related to technical careers, standing out in the field of science, technology, engineering and mathematics (STEM) (Botella et al., 2019; National Science Board, 2012; Rossi & Barajas, 2015). This horizontal gender segregation reflects that women and men access differentiated work environments. Women remain in the areas traditionally considered feminine, such as health, education and services, while men take the positions of a technical nature, currently better valued and with greater future projection.

This situation opens the following questions: why do these differences occur? What makes girls and boys choose different studies? Are there specific characteristics that determine a differentiated choice? Are there different beliefs about careers? Are there different images about the professions? Why are they?

The paper is organized as follows. Section 'An overview of gender differences in the choice of career' addresses the explanations of the barriers on the processes of career choice, gender stereotypes and segregated interests of career choice, interaction between stereotypes and interests, and a short description of data in Spain. In 'Methods' section, a description of the sampled data and the methods used for the analysis are presented. Section 'Results: gender stereotypes in technical studies' shows the results of the data analysis from the gender stereotypes in technical studies point of view. The paper concludes with a conclusions section.

An overview of gender differences in the career choice

Barriers on the choice process

In order to explain the situation presented above and try to answer the proposed questions, the theories on the processes of choice must be referenced, and more specifically, the processes of choice from a gender perspective. Eccles et al. (1984) showed the election process is influenced by cultural context, socialization processes and gender stereotypes. A bout the choice of a typically female or male career from a psychosocial perspective, López-Sáez (1995) includes as specific theoretical models to explain the differentiated choice between men and women: the self-concept theory, the attribution style theories, and the theories of the orientation to the overcoming and the theories of expectation-value.

These theoretical models reflect that the factors to explain gender segregation are multiple, complex and related to each other. The socialization process, cultural norms, gender identity, gender stereotypes and roles, and the lack of references can be highlighted among them. Then, multiple barriers cause gender gap in STEM. Women are dealing with several barriers in the professional career such as lack of mentors, lack of female role models, different perceived supports, barriers on self-efficacy beliefs, gender bias in the workplace or a male-dominated field (Botella et al., 2019; O'Connor, 2020; Peña-Calvo et al., 2016). These factors are interlinked and receive feedback from the others contributing to their development and maintenance, and they also influence the development of individual factors such as interest, motivation and expectations.

Gender stereotypes and career choice

Gender stereotypes make up one of the most important factors in explaining women segregation in all areas, and therefore also in the choice of career segregated. Gender stereotypes and gender roles influence self-concept, behavior and choices through their success expectation. In the present work, the focus will be on the attribution of gender stereotypes to different degrees and professions.

López-Sáez (1995) analyses the psychosocial characteristics of those who choose a professional role stereotypically attributed to their gender compared to those who choose a professional role stereotypically attributed to the opposite gender finding the following results: there are more differences between women with different roles than among men; women choosing male careers show more stereotypically male characteristics than female characteristics of men choosing female careers; communal or expressive values and motivations predominate in women, while agent or instrumental values and traits stand out in men; and, within the same profession, women's interests are oriented to the social field and tend to occupy positions of fewer prestige and economic status.

On the other hand, Sánchez García et al. (2011) analyze the presence of gender values and stereotypes based on some personal characteristics. The results reflect that, as age and educational level increase there are fewer gender stereotypes. There is a greater presence of gender stereotypes in men, while women tend to be more egalitarian or neutral in relation to gender stereotypes. In addition, these authors find that men give more importance to instrumental characteristics of work such as stability, security or salary, while women highlight values involved in the work, personal development and personal relationships, in line with other findings (Gati et al., 2006). These results reflect a perpetuation of gender stereotypes. In that sense, López-Sáez et al. (2008) found that the content of gender stereotypes was stable and confirming the classical assignment of expressive-communal traits to women and of instrumental-agentic traits to men.

Current research has also found that gender stereotypes explain girls' lower interest than boys in courses related to computer science (Master et al., 2016; Stout et al., 2016). In the first work, girls preferred to follow a computer course when the classroom reflected a non-stereotypical environment but they didn't choose these courses if the classroom had masculine and traditional objects. These stereotypes only affected the girls. If girls felt that they didn't belong to the environment they were less interested, but when they felt belonged to their classroom the computer science interest increased (Master et al., 2016). In the second work, Stout el al. (2016) found fewer women in STEM, but there were no gender differences when women perceived the field associated with communal aspects or gender-role congruent.

However, the differences between girls and boys appear in primary school, and their future education choices will be determined by the gender roles and stereotypes about careers attribution to men/women.

Gender differences and professional interests

Although there are no differences in academic results, girls show less interest and orientation to STEM or science careers (Catsambis, 1995; Morganson et al., 2010; Planty et al., 2009). In this sense, Moote et al. (2019) find that the interest in studying engineering careers was notably lower in girls than in boys, even from the age of 10. Andrews et al. (2021) consider that engineering identity is often lower for women than men.

Gati and Perez (2014) also find gender differences in career choice. Women prefer positions where technical skills are not required, while men prefer to implement such skills. Therefore, men tend to look for a job in the technological or engineering field, while women avoid these sectors. This differentiated choice may be due to the social conventions that maintain the stereotyped division of jobs and that makes women avoid environments dominated by men with lack of female roles (Faulkner, 2009; Ryu & Lee, 2013; Williams et al., 2012).

Although the perception of having specific skills influences the desire to develop them, it is the desire and the interest that determines preference in an election, more than the ability to develop such competences. Therefore, women with technical skills do not choose this professional field in response to what social norms determine, which limits and harms them (Gati et al., 2006). Therefore, although men and women share preferences in the general professional aspects, they point out different options when they have to indicate possible jobs (Gati & Perez, 2014).

Interaction of stereotypes and interests

As we mentioned before, gender stereotypes are interrelated to interests in choosing a career or a job. The fact that women avoid occupations related to STEM, and look for occupations with communal or expressive characteristics, is a consequence of the attribution of gender stereotypes and compliance with social norms, and not of an inherently feminine preference (Diekman et al., 2010). Sáinz and López-Sáez (2010) identified that women have lower computer attitudes than their male counterparts but it does not mean that attitudes towards computers are negative. Engineering is a profession included in a gendered occupations category, so men are more appropriated for the job than women based on gender stereotypes. As a result, female engineers are considered first as women and second as engineers (Hatmaker, 2013).

Barth et al. (2015) analyzed how occupational gender stereotypes affected the career preferences in women and men. Women expressed greater interest in feminine-stereotyped occupations than men. However, there are no differences in their job preferences, but differences are found in the case of men. They concluded that women were less influenced by gender stereotypes, and that a possible explanation could be that women involved in STEM courses have self-perceptions associated with masculine-stereotyped attributes. Furthermore, some occupational conditions as the salary could be important depending on the feminine-stereotyped conditions. At the beginning of their career, salary is considered very important, but when women have children, they consider more important the occupational family-friendly conditions.

Rossi and Barajas (2015) did not find significant differences between girls and boys in the quantitative study of future studies interest and both sexes reject stereotyped beliefs, but they found interesting details in the qualitative analysis. In this case, gender stereotypes were more rejected by those girls choosing STEM studies than by girls who selected other studies. In addition, both male and female students expressed that girls were more interested in the social field and less in technical studies, while boys were more interested in the technical field. Moreover, boys pointed out that technical professions were more profitable and prestigious, and they also appreciated high salaries. On the other hand, girls and boys considered that to be good at math does not depend on gender and they believe that both genders have the same skills, however the girls ended up stating that boys are better at technology. In the same way, Kersey et al. (2018) found that there were no differences between girls and boys in mathematical abilities. Therefore, if gender stereotypes are not recognized at the beginning, the stereotyped gender association will characterize their choices as they progress in their studies.

According to the above discussion, some studies confirmed that STEM science is seen as a male gendered profession (Berg et al., 2018; Capobianco et al., 2013; Wong, 2016). Gender stereotypes, role models, and media influence determine the career choice of women. Berg et al. (2018) analyzed the children's perception about women in computing science. Their findings showed that girls and boys perceived that computing is male oriented and not suitable for certain girls.

Data on the situation in Spain

The data analyzed by the authors have confirmed gender differences in specific areas of STEM in High School. Next, we show a general description of this situation in the Spanish context, specifically, in the Valencia Community. Table 1 shows that girls are studying more than boys in all areas except in Sciences. Only students who choose sciences subjects may choose, in the future, technical degrees such as engineering or architecture. Therefore, although there are more girls than boys studying in High School both in Spain (53.5%) and in the Valencian Community (54.7%), there are fewer girls who can choose a career linked to STEM.

In relation to the percentage of new students enrolled in the University, we can see the same results in the High School. Table 2 shows that women are more than men in all

Table 1 High School students in specific areas by gender (2017–2018).

Studies	Spain		Valencian Community	
	Boys	Girls	Boys	Girls
Sciences	154,875(53)	137,507(47)	13,889(51.8)	12,922(48.2)
Humanities	21,973(36.7)	37,914(63.3)	2744(33.1)	5534(66.9)
Social Sciences	58,655(45.1)	71,335(54.9)	9564(44.4)	11,977(55.6)
Humanities & Social Sciences	47,737(41.4)	67,488(58.6)	32(62.7)	19(37.3)
Arts	10,777(31.5)	23,409(68.5)	1039(30.1)	2418(69.9)
Total	294,017(46.5)	337,653(53.5)	27,268(45.3)	32,870(54.7)

Figures are presented as total amount, and percentage in parentheses. (Ministerio de Educación y Formación Profesional, 2019)

Table 2 New university students in specific areas by gender (2018–2019)

Studies	Spain		Valencian Community	
	Men	Women	Men	Women
Social & Law Sciences	63,766(40.4)	93,998(59.6)	5047(37.8)	8298(62.2)
Engineering & Architecture	44,556(76.6)	13,594(23.4)	4687(73.7)	1669(26.3)
Arts & Humanities	14,870(39.1)	23,122(60.9)	883(31)	1963(69)
Health Sciences	17,621(28.7)	43,774(71.3)	1988(29.8)	4678(70.2)
Sciences	10,894(50.1)	10,860(49.9)	764(44.1)	969(55.9)
Total	151,707(45)	185,348(55)	13,369(43.2)	17,577(56.8)

Figures are presented as total amount, and percentage in parentheses. (Ministerio de Educación y Formación Profesional, 2019)

degrees except in Sciences and in Engineering and Architecture. However, in Sciences are very similar. In Spain, men and women are around 50% but in the Valencian Community women are almost 56% and men 44%. In the case of Engineering & Architecture the differences between men and women are very important. In Spain, men are 76.6% and women just 23.4%. In the Valencian Community the differences are similar than in Spain, men are 73.7% and women 26.3%.

Valencian Community Public University System data is used in this study as an example due to the easy access to this data for the authors, but similar conclusions can be drawn from other areas. Table 3 shows the results of the two main Public Universities of Valencia. Polytechnic University of Valencia includes mostly studies linked to Engineering and University of Valencia has more degrees in the rest of fields than in Engineering. Men represent 72% of Engineering & Architecture but only 21.8% of Arts & Humanities and 31% of Sciences. In the University of Valencia women are always more than men except in Engineering that men are the 79.3% and women 20.7%, and in Sciences that there are the same percentage.

Table 4 highlights the differences between men and women in some degrees of Polytechnic University of Valencia. Similar percentages can be seen in Architecture. However, in the rest of degrees men represent much higher percentages than women. For

Table 3 New university students in specific areas by gender (2018–2019) from the Valencian Public Universities

Studies	Polytechnic University of Valencia		University of Valencia	
	Men	Women	Men	Women
Social & Law Sciences	366(52.4)	333(47.6)	1635(36.6)	2838(63.4)
Engineering & Architecture	2658(72)	1035(28)	391(79.3)	102(20.7)
Arts & Humanities	135(21.8)	485(78.2)	412(36.8)	709(63.2)
Health Sciences			470(23.7)	1510(76.3)
Sciences	75(31)	167(69)	389(49.4)	398(50.6)
Total	3234(61.6)	2020(38.4)	3297(37.2)	5557(62.8)

Figures are presented as total amount, and percentage in parentheses. (Ministerio de Educación y Formación Profesional, 2019)

Table 4 Polytechnic University of Valencia by gender (2018–2019)

Studies	Men	Women
Architecture	245(48.9)	256(51.1)
Civil Engineering	93(80.9)	22(19.1)
Industrial Engineering	271(73)	100(27)
Mechanical Engineering	226(85.3)	39(14.7)
Geomatics & Topography Engineering	93(83)	19(17)
Informatics Engineering	474(89.3)	57(10.7)
Agronomy Engineering	115(69.7)	165(30.3)
Telecommunication Engineering	396(79.7)	101(20.3)

Figures are presented as total amount, and percentage in parentheses

instance, 89.3% of men are studying Informatics Engineering and 85.3% Mechanical Engineering.

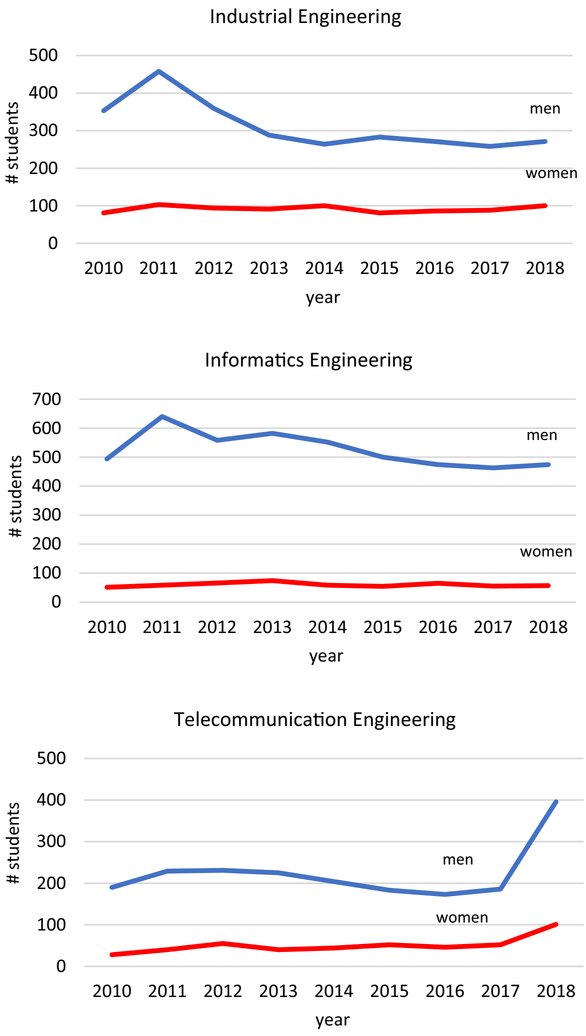
Finally, as an example, Fig. 1 shows the time evolution of the number of students in some degrees in the Polytechnic University of Valencia (UPV). From 2010 until 2018, the differences between the number of enrolled men and women are very important.

The theoretical review carried out up to this point can be summarized in the following specific conclusions: there are still differences in the choice of studies between girls and boys, and there are less girls than boys choosing careers linked to STEM; there are many factors that contribute to maintain the gender segregation and that interact among them; and there is no total agreement on the influence of these factors, but the stereotyped gender attribution is very important to explain the situation.

The Polytechnic University of Valencia (UPV) is very concerned with the issue of the low number of women in technical careers. Considering this, UPV has made different initiatives with the purpose of increasing the presence of women in technical degrees. As a result of its participation in different gender-related European projects, UPV developed the Valentina Program in the 2007–2008 academic year. This program, which takes the name of Valentina Tereshkova in honor of the first woman who traveled to space in 1937, included a diagnostic study on the reasons and barriers that determine the lowest percentages of women in technical studies, awareness workshops aimed at students in 3rd and 4th ESO, and the development of a mini-series designed to disseminate it on the Internet and through social networks. The data gathered in the Valentina Program diagnostic study has been analyzed in detail in this work trying to put some light on the reason leading to the conclusions of theoretical review carried in this section. The general aim of this work is *to analyze the existence of gender stereotypes attributed to studies in a sample of Valencian secondary students* and it was operationalized with the following objectives:

- Firstly, to analyze the differences between girls and boys. Boys attributed more gender stereotypes than girls in studies and degrees.
- Secondly, to analyze the differences between students with the intention to pursue STEM. Students who intend to study engineering have fewer gender stereotypes than students who do not intend to study engineering.
- Thirdly, to evaluate the existence of student profiles that attributed gender stereotypes to the studies.
- And fourthly, to test the time evolution of gender stereotypes attribution in the students.

Fig. 1 Example of the evolution of the number of students from 2010 to 2018 in some STEM degrees in the Polytechnic University of Valencia (UPV). The plots present the women data in red and men data in blue



Methods

Participants

The sample comprised 1844 secondary students: 928 boys (50.3%) and 916 girls (49.7%), with ages between 14 and 22 years (mean age 15.9 years old; SD = 1.15). They were enrolled in the 4th course of *ESO* (final year of compulsory secondary education) and 1st course of *Bachillerato* (first of the 2 prior years to university studies) in high schools located in the Valencian Community. For this study, we haven't considered other characteristics of the sample, although High Schools participate in the study voluntarily, and all together represent general characteristics of the Valencian population. We have focused on the general opinions of the students at the High School, regardless of other personal or general (religious, cultural, ethnic, …) characteristics that it would be interesting to address in future studies. Table 5 shows the sample distribution.

In order to develop comparative analysis, the sample is divided into different groups: one group with students who would like to study engineering (577 students, 392 boys and 185 girls) and the other one with students who wouldn't like to study engineering (1267 students, 536 boys and 731 girls). The study was carried out between 2008 and 2017. The time variable allows us to analyze the evolution of stereotypes, for which two stages are established: the first stage includes the students who answered the survey between 2008 and 2010 (n = 1148), and the second stage includes the students who answered the survey between 2014 and 2017 (n = 696). The samples of both stages are similar, because students came from the same schools and the same grades.

Instruments

A survey to the secondary students has been designed and distributed. The survey aimed to collect data on the perception of gender stereotypes in relation to technical studies/professions and degree choice. The survey is divided into three parts. First part includes three items about sociodemographic data: sex, age and name of high school. Second part is related to the studies choice and motivation for this election including five questions: the subjects' choice, people who influenced in the subjects choice, motives for subjects choice, perception of competence to past subjects, and intention to study an engineering. The survey includes a third part about gender stereotypes attribution. The full survey belongs to a wider research, but this paper is only focused on three questions, besides of the sociodemographic data.

The present survey includes an item related to the intention to study an engineering that students should answer yes or no: Have you considered studying an engineering? And two items of the third part of the survey, where students were asked to link some subjects and degrees with men, women or both, men and women, as suitable to develop this kind of professions. In relation to the subjects, students were asked about eight secondary subjects such as Technology, Biology or Languages: Do you think there are more appropriate subjects for men or women? In case of the degrees, students were asked about 13 such as Biology, Psychology, Architecture or Industrial Engineering: Do you think that the professions associated with these degrees, are better performed by a man, a woman or both equally? The survey obtains a Cronbach's Alpha value of .72, what indicates an acceptable level of reliability.

Table 5 Sample composition

	Boys	Girls	Total
Participants	928 (50.3)	916 (49.7)	1844 (100)
Study ENG—yes	392 (68)	185 (32)	577 (100)
Study ENG—no	536 (42)	731 (58)	1267 (100)
Stage 1: 2008–2010	577 (50.2)	571 (49.8)	1148 (100)
Stage 2: 2014–2017	351 (50.4)	345 49.6)	696 (100)

Figures are presented as total amount, and percentage in parentheses

A quantitative analysis of the answers of the students to the third part of the survey has been performed using different data analysis techniques, and results are presented in detail in 'Methods' section.

Data analysis

The Statistical Package for the Social Sciences (SPSS version 21) is the software tool used for data analysis. First of all, the Chi-Squared Test was used to determine whether there is a significant difference between answer frequencies.

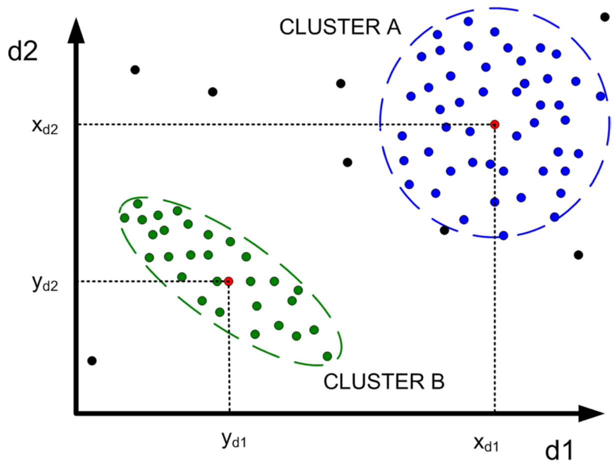
Secondly, cluster analysis has been applied to identify whether hidden groups of behavior exist among students. Clustering is an unsupervised learning classification technique, whose aim is to obtain clusters of data, grouped by similarity, where similarity is computed as a mathematical function of distance between two objects (Bezdek, 1981).

Typically, the clustering is a classification process done on groups of objects from a database. The objects are entities that are formed by a number *n* of characteristics or dimensions, thus the objects are n-dimensional. The resulting clusters are therefore represented by a number *c* of centroids or pattern prototypes, usually one per cluster, which are also n-dimensional. Figure 2 displays an example of clustering in a set of 2D objects.

The centroids usually coincide with the center of gravity of the cluster, however this may vary, according to the algorithms used and the data types being classified. The K-means algorithm (Oliveira & Pedrycz, 2007) is one of the most known and used clustering algorithm, due to its efficiency and robustness. The name refers to the number *k* of clusters to be found, defined as an initial parameter. The procedure of the algorithm is the following:

1. Select *k* objects and set them as the initial prototypes of the *k* clusters to be found. This can be done randomly from the data set.
2. Compute all the Euclidean distances of the remaining objects to the *k* prototypes. Assign each object to the cluster with the smallest distance.
3. Compute clusters prototypes or centroids as the average or mean value from all the objects that belong to the cluster, with the objective to minimize the function shown in

Fig. 2 Example of two clusters (A and B) and their respective centroids (x_{d1},x_{d2}) and (y_{d1},y_{d2}) on a 2D data set



Eq. (1). This objective function is a summation of all the k summations of the distances from all the objects to the centroid of each cluster.

4. Proceed with the two previous steps until a termination condition is reached, like the variation in centroids falling under a predefined limit.

$$J = \sum_{i=1}^{k} \sum_{j, z_j \in A_i} \left\| z_j - c_i \right\|^2 \tag{1}$$

The efficiency of the K-means algorithm highly relies on the parameter of the number of clusters to be found, its adequacy to the real number of clusters, and the initialization of prototypes.

Procedure

The data collection of the survey on the perception of gender stereotypes in relation to technical studies/professions and degree choice was conducted on several public-funded high schools located in the Valencian Community (Spain). The survey was delivered in class during the academic years 2008–2017. The procedures established to carry out the study were designed following the good practices established by the university, and the current legal requirements were followed.

In summary, the procedure is described in the following. The high schools managerial teams were informed some weeks before the activity, they were involved voluntary and they had the regional government permission to perform such kind of activities with their students. At each school, students were informed some days before to the activity by their tutor. The students were also informed, in a simple and understandable way, by the researchers about the survey and research objectives just before starting the survey. Participants were encouraged to answer the questionnaire as honestly as possible, because there weren't right or wrong answers. The students were also informed about the anonymous collection and treatment of the responses to the survey. Participation in the study was voluntary and subjects were able to withdraw at any time. The students did not receive financial compensation for their participation in the study. Once all anonymous survey forms from a particular class were all filled in, they were introduced in an envelope without any information about students. After that, all the data in the surveys was introduced manually in a spreadsheet for subsequent data analysis, and original paper surveys were destroyed then being impossible to link answers to students in any way.

Results: gender stereotypes in technical studies

How students perceive the gender profile of studies, mainly technical studies, is analyzed. The gender profile of studies can be operationalized through the attribution of studies to men, to women or both (neutral). The link of one degree to men or women, means the presence of gender stereotypes, while the link to both men and women means an equal gender perception of the studies.

The gender profile of the studies perceived by the secondary school students is analyzed in the first section of results. First of all, the percentages of stereotyped and neutral answers are calculated in the whole sample. Secondly, the same analysis is done separately for boys and girls answers and significant differences between answer frequencies of the two groups are showed. Thirdly, the analysis is repeated but separating the data using the intention to study engineering of the students. Finally, an automatic classification of the answers is done by means of clustering trying to detect different groups of behavior among students.

The evolution of gender stereotypes is also analyzed considering two stages: 2008–2010 period (stage 1) and 2014–2017 period (stage 2). It is done in the second part of the results section with the aim of looking for changes along time in the students' perception about the gender profile of studies, where the analysis performed in the first section is repeated but considering changes with time.

Gender stereotypes perceived by the secondary school students

Gender stereotypes in the whole sample

The level of gender stereotypes in each university degree included in the survey can be identified. Table 6 offers the percentage of answers that attribute the studies to men (M), women (W) of both (B). The studies with highest levels of masculine stereotypes are Physical Activity and Sport Sciences, Technology (Secondary subject), Industrial Engineering, Architecture and Informatics Engineering. The studies with highest levels of feminine stereotypes are Pharmacy, Psychology and Educational Sciences.

Gender stereotypes by sex

The perception of stereotypes in both boys and girls has been evaluated, and is summarized in the Table 7. The Chi-Squared Test allows to check the dependence of sex and stereotypes variables. The relation between sex and perception of stereotypes can be seen in all studies, except in Agronomy and Aerospace Engineering.

Table 6 Gender stereotypes of studies

Studies	% of answers		
	Men	Women	Both
Technology (secondary subject)	28.6	0.9	70.5
Physical Activity and Sport Sciences	32	0.7	67.4
Biology	1.6	10.6	87.9
Education Sciences	1.5	18.2	80.4
Pharmacy	1.1	26.4	72.5
Physics	14	2.3	83.7
Psychology	1.8	20.1	78.1
Architecture	19.1	1.4	79.5
Agronomy Eng.	15.3	4	80.7
Industrial Eng.	22.5	1	76.5
Informatics Eng.	18.8	1.7	79.5
Chemical Eng.	13.4	3.9	82.8
Telecommunication Eng.	6.4	5	88.6
Aerospace Eng.	17.2	0.6	82.2

Table 7 Gender stereotypes in boys and girls

Studies	Boys			Girls			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	32.4	1	66.6	24.7	0.9	74.5	13.806	.001**
Physical Activity and Sport Sc.	38.3	0.8	61	25.7	0.5	73.8	34.406	.000**
Biology	2.4	12.3	85.3	0.8	8.8	90.4	14.066	.001**
Education Sciences	2.2	21.3	76.5	0.8	15	84.3	19.883	.000**
Pharmacy	1.9	29.1	69	0.3	23.6	76.1	19.067	.000**
Physics	17.9	3.1	79	10	1.4	88.5	31.184	.000**
Psychology	2.8	21.8	75.4	0.8	18.4	80.8	14.906	.001**
Architecture	22.4	1.3	76.3	15.8	1.4	82.8	12.911	.002**
Agronomy Eng.	15.6	4.4	80	15.1	3.5	81.4	1.215	.545
Industrial Eng.	25.4	1.1	73.5	19.5	0.9	79.6	9.539	.008**
Informatics Eng.	22.5	1.5	76	15.1	1.9	83.1	16.879	.000**
Chemical Eng.	15.8	4.4	79.7	10.9	3.3	85.8	11.957	.003**
Telecommunication Eng.	8.3	5.3	86.4	4.5	4.8	90.7	11.689	.003**
Aerospace Eng.	19	0.5	80.5	15.5	0.7	83.8	3.939	.140

Statistical differences with significance levels of *$p \leq .05$ and **$p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

The results show that boys have more stereotyped answers than girls. The percentage of boys that link the studies to men or women, depending on the stereotype, is always higher than the percentage of girls.

Gender stereotypes by intention to study engineering

Next table (Table 8) shows the stereotypes perception comparing students who want to study an engineering and those who do not want to study an engineering degree. Students close to engineering have more stereotypes in relation to Physics and Informatics Engineering, but no differences have been found in the rest of studies.

Students' gender stereotypes profiles

The k-means algorithm explained in section 'Gender differences and professional interests' has been used in the clustering of the available database with the aim of detecting different groups of behaviors within the participants. In order to do so, a three characteristics object has been created for each subject following the structure: [# of men professions, # of neutral professions, # of women professions]. Then, the whole database has been clustered into three groups. The optimal number of groups (clusters) has been determined through extensive simulations considering that clusters must be different among them and reflect the different behaviors within the data. Three cluster centroids (pattern prototypes) have been detected automatically, and they correspond to the three gender stereotype profiles shown in Fig. 3.

Table 8 Gender stereotypes by intention to study engineering

Studies	Yes engineering			No engineering			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	28.6	1.2	70.2	28.6	0.8	70.6	0.784	.676
Physical Activity and Sport Sc.	31.9	1	67.1	32	0.5	67.5	1.967	.374
Biology	1.2	12.1	86.7	1.7	9.9	88.4	2.752	.253
Education Sciences	1.2	18.7	80.1	1.6	17.9	80.5	0.511	.775
Pharmacy	1.4	26.7	71.9	1	26.2	72.8	0.527	.768
Physics	17.3	1.9	80.8	12.5	2.4	85.1	8.086	.018*
Psychology	1.2	20.1	78.7	2.1	20.1	77.8	1.597	.450
Architecture	17.5	1.6	80.9	19.9	1.3	78.8	1.654	.437
Agronomy Eng.	13.5	4.5	82	16.2	3.7	80.1	2.637	.268
Industrial Eng.	22.2	1	76.8	22.7	0.9	76.4	0.081	.960
Informatics Eng.	21.1	0.7	78.2	17.8	2.1	80.1	7.479	.024*
Chemical Eng.	13.3	3.5	83.2	13.4	4	82.6	0.342	.843
Telecommunication Eng.	6.8	3.5	89.8	6.2	5.8	88	4.452	.108
Aerospace Eng.	17	0.5	82.5	17.4	0.6	82	0.127	.938

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

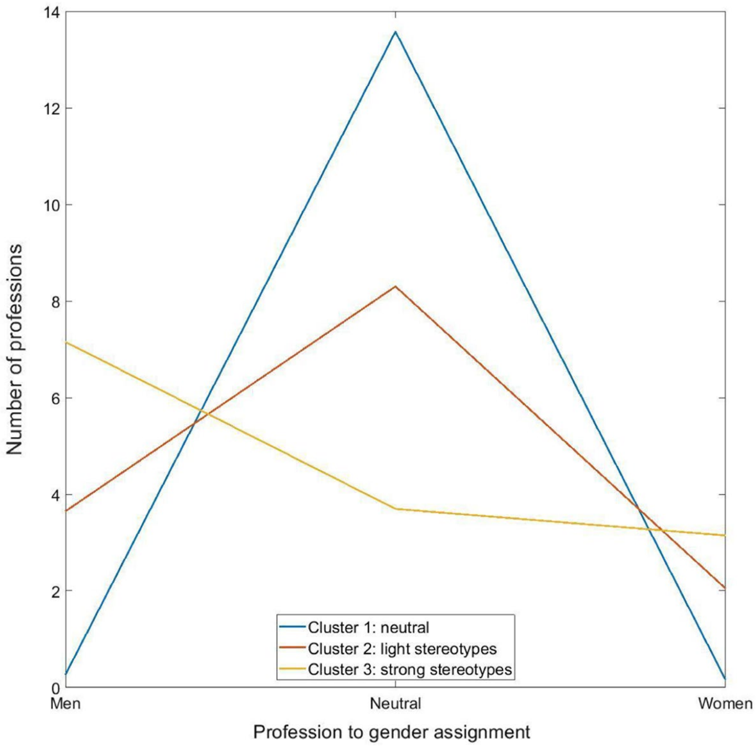


Fig. 3 Clusters found in the database considering all the students

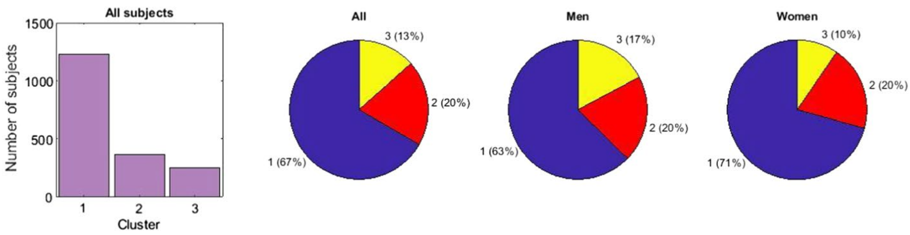


Fig. 4 Analysis of the clusters composition in the whole database

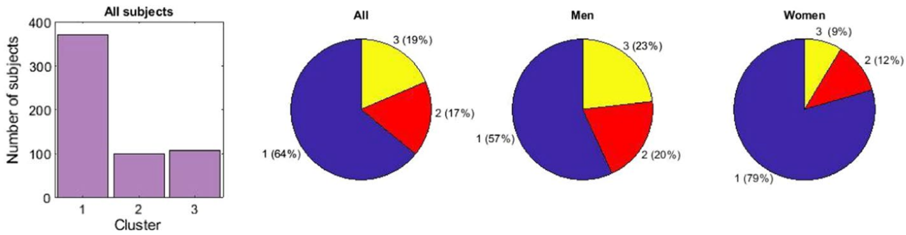


Fig. 5 Analysis of the clusters composition for students considering enrolling in engineering degrees

The same results have been found when the clustering process is done only over the students considering engineering as an option for their studies and for those not doing so. The three clusters represent:

– Cluster 1 (blue): participants without stereotypes. The number of professions considered more adequate for men or women is null, and all of them are neutral.
– Cluster 2 (red): participants with light stereotypes. The number of professions considered more adequate for men or women is small, and most of the professions are considered neutral.
– Cluster 3 (yellow): participants with strong stereotypes. Most professions are considered for men, and only a few professions are considered neutral or for women.

Figure 4 gives some hints about the clusters composition and the students belonging to each cluster. The number of students in cluster 1 is high (67%), but 33% of students have stereotypes and are included in cluster 2 (20%) and cluster 3 (13%). Regarding gender distribution, some differences appear: most girls are in cluster 1 (71%), where only 63% of boys are allocated. Additionally, in cluster 2 there are 20% of boys and 20% of girls; and in cluster 3 there are 17% of boys and 10% of girls.

These results are similar to those obtained through the comparison of percentages carried out before (Table 7). Regarding gender, boys show higher levels of stereotypes than girls, while girls show higher levels of neutral answers. The differences by the sex variable are even greater in the profiles of students who want to study engineering (see Fig. 5).

The 577 students (392 boys, and 185 girls) considering enrolling in engineering degrees have been studied separately. Figure 5 shows that the number of students in cluster 1 is high (almost 400, 64%) but about 100 are included in cluster 2 (17%) and cluster 3 (19%). Regarding gender distribution, differences are very important in this case: most girls are more in cluster 1 (79%), where only 57% of boys are allocated. Additionally, in cluster 2 there are 20% of boys and 12% of girls; and in cluster 3 there are 23% of boys and 9% of girls.

Students who are not considering enrolling in engineering degrees have also been studied separately. Figure 6 shows a distribution very similar to the data in the whole database: 66% of students are in cluster 1, 21% are included in cluster 2, and 13% are in cluster 3.

Regarding gender distribution, most girls are more in cluster 1 (68%), where 63% of boys are allocated. Additionally, in cluster 2 there are 21% of boys and 21% of girls; and in cluster 3 there are 15% of boys and 11% of girls.

Evolution of gender stereotypes perceived by the secondary school students

Evolution of gender stereotypes in the whole sample

The whole sample has been divided into two stages to analyze the evolution of stereotypes (Table 9). First stage includes 1148 students (62% of the sample) from 2008 to 2010, and second stage includes 696 students (38% of the sample) from 2014 to 2017.

There are two different ways of evolution in the stereotyped perception of studies (Table 10). On one hand, an increase of the stereotyped perception can be noted, through the growth of percentages of answers correlating studies to men or women, or through the decrease of percentages of neutral answers (*the studies are suitable for both men and women*). The growth of the masculine stereotyped perception happens in the studies of Architecture, Informatics, Telecommunication, and Aerospace Engineering. Moreover, there is a growth of the feminine stereotyped perception in the Psychology degree. On the other hand, a decrease of the stereotyped perception can be observed in the studies of Technology (Secondary subject), Pharmacy and Chemical Engineering.

Evolution of gender stereotypes by sex

The evolution of gender stereotypes according to sex variable has been analyzed, in order to verify whether the change of stereotypes occurs in boys and girls (Table 11).

Results show a change of stereotypes between boys in two ways: first, a growth of the stereotyped perception between boys in the studies of Telecommunication and Aerospace Engineering. There is a rise of the percentage of boys that consider these degrees as suitable for man, and fewer students think that are suitable for both men and women. Secondly, a decrease of stereotypes in the studies of Technology (Secondary subject), Pharmacy and Chemical Engineering. The percentage of boys that think these studies are suitable for both women and men is higher in the second stage (2014–2017).

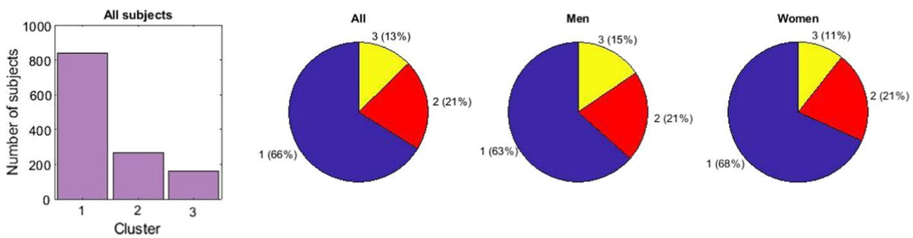


Fig. 6 Analysis of the clusters composition for students not considering enrolling in engineering

Table 9 Evolution of gender stereotypes

Studies	2008–2010			2014–2017			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	32	1	67	23	0.7	76.3	18.053	.000**
Physical Activity and Sport Sc.	32.4	0.8	66.8	31.3	0.4	68.2	1.121	.571
Biology	1.8	10.9	87.3	1.1	10.1	88.8	1.669	.434
Education Sciences	1.9	18.1	80	0.7	18.2	81	4.313	.116
Pharmacy	1.7	28.2	70.1	0.3	23.2	76.4	13.524	.001**
Physics	15.5	2.4	82.1	11.5	2.2	86.4	5.972	.050
Psychology	2.4	19.2	78.4	0.7	21.7	77.6	8.585	.014*
Architecture	17.1	1.6	81.4	22.6	1	76.4	9.139	.010*
Agronomy Eng.	15.2	3.7	81.1	15.5	4.5	80	0.775	.679
Industrial Eng.	21.3	1	77.7	24.4	1	74.6	2.396	.302
Informatics Eng.	16.4	2	81.6	22.8	1.1	76	13.233	.001**
Chemical Eng.	16.1	3.1	80.7	8.9	5	86.1	22.312	.000**
Telecommunication Eng.	4. 4	4.6	91	9.8	5.7	84.5	23.047	.000**
Aerospace Eng.	12.9	0.4	86.7	24.4	0.9	74.7	42.287	.000**

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

Table 10 Evolution of masculine and feminine stereotypes

Stereotypes	Increase	Decrease
Feminine	Psychology	Pharmacy
Masculine	Architecture Informatics Engineering Telecommunication Eng. Aerospace Engineering	Technology (secondary subject) Chemical Engineering

Girls show similar results than boys about the decrease of the stereotyped perception of studies of Technology (Secondary subject), Pharmacy and Chemical Engineering (Table 12). However, girls show higher levels of stereotypes in more degrees than men (Architecture, Informatics Eng., Telecommunications Eng., Aerospace Eng., and Psychology).

Evolution of gender stereotypes by planning to study engineering

One of the questions included in the survey was "Are you planning to study an engineering degree?" A third part of the sample (577, 31%) answered "yes" to this question, and 1267 (69%) said "no". The evolution of gender stereotypes in those groups of students has been analyzed. First, results of students who want to study an engineering are shown in Table 13.

Students who are planning to study an engineering degree show a change in their perception about gender and studies. More stereotypes were found in Architecture, Informatics and Aerospace Engineering, and less stereotypes in Chemical Engineering, in the second

Table 11 Evolution of gender stereotypes in boys

Studies	2008–2010			2014–2017			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	35.9	1.4	62.7	26.8	0.3	72.9	11.703	.003**
Physical Activity and Sport Sc.	39.7	1	59.3	35.9	0.3	63.8	3.208	.201
Biology	2.8	12.3	84.9	1.7	12.3	86	1.074	.585
Education Sciences	2.8	22.4	74.9	1.1	19.7	79.2	3.982	.137
Pharmacy	2.8	30	67.2	0.6	27.6	71.8	6.530	.038*
Physics	19.4	2.9	77.6	15.4	3.4	81.2	2.438	.289
Psychology	3.6	21.7	74.7	1.4	21.9	76.6	3.938	.140
Architecture	21.1	1.2	77.6	24.5	1.4	74.1	1.537	.464
Agronomy Eng.	16.3	3.6	80.1	14.5	5.7	79.8	2.529	.282
Industrial Eng.	24.6	1.2	74.2	26.8	0.9	72.4	0.762	.683
Informatics Eng.	21	1.9	77.1	25.1	0.9	74.1	3.497	.174
Chemical Eng.	18.4	3.5	78.2	11.7	6	82.3	9.771	.008**
Telecommunication Eng.	6.8	4.2	89.1	10.8	7.1	82.1	9.228	.010*
Aerospace Eng.	15.3	0.3	84.4	25.1	0.9	74.1	15.034	.001**

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

Table 12 Evolution of gender stereotypes in girls

Studies	2008–2010			2014–2017			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	28	0.7	71.3	19.1	1.2	79.7	9.462	.009**
Physical Activity and Sport Sc.	25	0.5	74.4	26.7	0.6	72.8	0.314	.855
Biology	0.9	9.5	89.7	0.6	7.8	91.6	0.982	.612
Education Sciences	1.1	13.8	85.1	0.3	16.8	82.9	3.028	.220
Pharmacy	0.5	26.4	73	0	18.8	81.2	8.954	.011*
Physics	11.6	1.8	86.7	7.5	0.9	91.6	5.227	.073
Psychology	1.2	16.6	82.1	0	21.4	78.6	7.271	.026*
Architecture	13	1.9	85.1	20.6	0.6	78.8	11.660	.003**
Agronomy Eng.	14.2	3.7	82.1	16.5	3.2	80.3	1.017	.602
Industrial Eng.	18	0.7	81.3	22	1.2	76.8	2.806	.246
Informatics Eng.	11.7	2.1	86.2	20.6	1.4	78	13.401	.001**
Chemical Eng.	13.8	2.8	83.4	6.1	4.1	89.9	13.919	.001**
Telecommunication Eng.	1.9	5.1	93	8.7	4.3	87	23.120	.000**
Aerospace Eng.	10.5	0.5	89	23.8	0.9	75.4	29.530	.000**

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

Table 13 Evolution of gender stereotypes in students who want to study an engineering

Studies	2008–2010			2014–2017			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	30.1	1.6	68.3	25.9	0.5	73.7	2.760	.252
Physical Activity and Sport Sc.	29.8	1.3	68.8	35.6	0.5	63.9	2.788	.248
Biology	1.1	11.6	87.4	1.5	13.2	85.4	0.508	.776
Education Sciences	1.3	16.9	81.7	1	22	77	2.281	.320
Pharmacy	1.9	26.3	71.8	0.5	27.3	72.2	1.902	.386
Physics	17.5	1.9	80.6	17	2	81	0.017	.991
Psychology	1.3	19.9	78.8	1	20.5	78.5	0.172	.918
Architecture	14.5	1.9	83.6	22.9	1	76.1	6.957	.031*
Agronomy Eng.	13.2	4	82.8	14.1	5.4	80.5	0.700	.705
Industrial Eng.	20.4	0.8	78.8	25.4	1.5	73.2	2.538	.281
Informatics Eng.	18	0.8	81.2	26.8	0.5	72.7	6.276	.043*
Chemical Eng.	15.9	2.7	81.5	8.8	4.9	86.3	7.173	.028*
Telecommunication Eng.	5.4	2.7	91.9	9.3	4.9	85.9	5.335	.069
Aerospace Eng.	11.3	0.5	88.2	27.3	0.5	72.2	24.084	.000**

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B)

Table 14 Evolution of gender stereotypes in students who don't want to study an engineering

Studies	2008–2010			2014–2017			Chi^2	p
	M	W	B	M	W	B		
Technology (secondary subject)	32.9	0.8	66.4	21.8	0.8	77.4	18.078	.000**
Physical Activity and Sport Sc.	33.6	0.5	65.9	29.5	0.4	70.1	2.444	.295
Biology	2.2	10.6	87.2	1	8.8	90.2	3.681	.159
Education Sciences	2.2	18.7	79.1	0.6	16.7	82.7	5.890	.053
Pharmacy	1.5	29.1	69.4	0.2	21.6	78.2	15.057	.001**
Physics	14.6	2.6	82.9	9.2	2.2	88.6	8.325	.016*
Psychology	3	18.8	78.2	0.6	22.2	77.2	9.866	.007**
Architecture	18.3	1.4	80.3	22.4	1	76.6	3.450	.178
Agronomy Eng.	16.2	3.5	80.3	16.1	4.1	79.8	0.298	.862
Industrial Eng.	21.8	1	77.2	24	0.8	75.2	0.987	.611
Informatics Eng.	15.6	2.6	81.8	21.2	1.4	77.4	7.899	.019*
Chemical Eng.	16.2	3.4	80.4	9	5.1	85.9	15.245	.000**
Telecommunication Eng.	3.9	5.5	90.6	10	6.1	83.9	19.722	.000**
Aerospace Eng.	13.7	0.3	86	23.2	2	75.8	21.531	.000**

Statistical differences with significance levels of $*p \leq .05$ and $**p \leq .01$. Columns M, W and B, show the percentage of students that associate the studies to men (M), women (W) or both (B) stage (2014–2017) of the study. Next, results of students who do not want to study an engineering will be shown in Table 14.

This group shows more changes in the evolution of gender stereotypes. Students who do not want to study engineering show more stereotypes in the second stage (2014–2017), in relation to Psychology, Informatics, Telecommunication and Aerospace Engineering; and less stereotypes in Technology (Secondary subject), Educational Sciences, Pharmacy, and Chemical Engineering.

In order to expose the results more clearly, Table 15 show a summary of main results about the evolution of gender stereotypes.

Evolution of gender stereotypes profiles

The independent analysis of the data in batch 1 (first stage, from 2008 to 2010) and batch 2 (second stage, from 2014 to 2017) give a similar distribution of students in the previously defined clusters when the whole data is considered (see Fig. 7). The same result is found in the case of the students not considering enrolling in engineering (Fig. 8). It can be observed that the number of students in cluster 1 (neutral) increases with time but at the same time there is an increase in the cluster 3 (strong stereotype) being both increases at an expense of cluster 2 (light stereotype). In some way, the extreme stereotypes are increasing among students.

The analysis gives different results in the case of students considering enrolling in engineering degrees (Fig. 9). A similar behavior is observed for boys (372) but, in the case of girls (204), results are especially worrying: the number of girls is decreasing with time in cluster 1 (neutral, from 84 to 70%) while increasing in clusters 2 (light stereotype, from 10 to 15%) and 3 (strong stereotype, from 6 to 15%). Therefore, the total number of girls with stereotypes doubles from 16 to 31% in the analyzed period.

Table 15 Evolution of gender stereotypes

Sample	Increase	Decrease
Whole sample	Architecture Informatics Engineering Telecommunication Eng. Aerospace Engineering Psychology	Technology (secondary subject) Chemical Engineering Pharmacy
Boys	Telecommunication Eng. Aerospace Engineering	Technology (secondary subject) Chemical Engineering Pharmacy
Girls	Architecture Informatics Engineering Telecommunication Eng. Aerospace Engineering Psychology	Technology (secondary subject) Chemical Engineering Pharmacy
Yes—engineering	Architecture Informatics Engineering Aerospace Engineering	Chemical Engineering
No—engineering	Informatics Engineering Telecommunication Eng. Aerospace Engineering Psychology	Technology (secondary subject) Chemical Engineering Pharmacy Educational Sciences

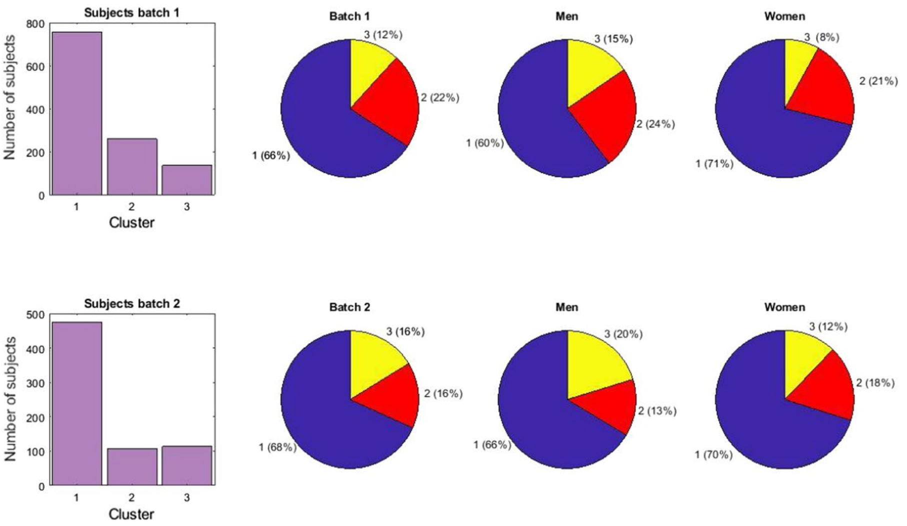


Fig. 7 Analysis of the clusters composition evolution with time for all the students

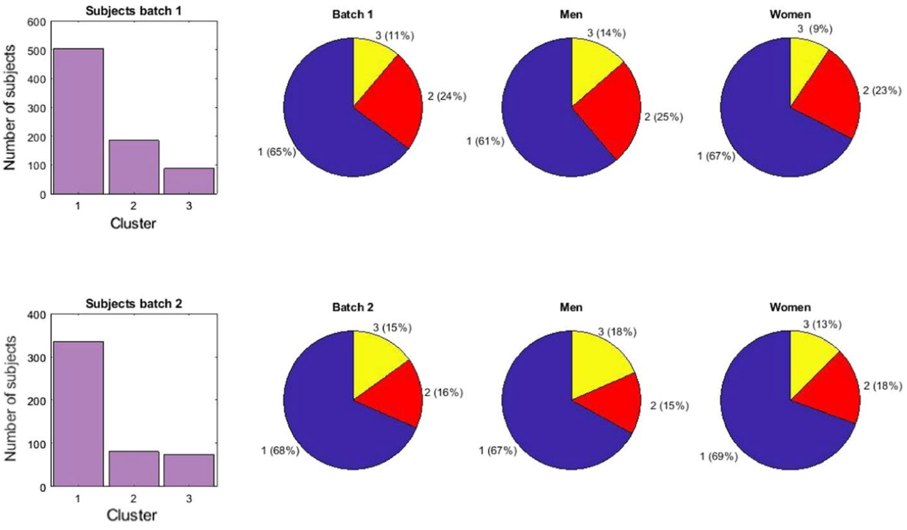


Fig. 8 Analysis of the clusters composition for students not considering enrolling in engineering degrees

Discussion

The analysis of gender stereotypes in the whole sample shows that studies linked to men are those related to the masculine role (for example, Physical Activity and Sport Sciences, Technology, or Industrial Engineering). Otherwise, the studies linked to women are related to the feminine role (for example, Pharmacy, Psychology and Education Sciences). Traditional roles and stereotypes of masculinity and femininity are present in the perception of

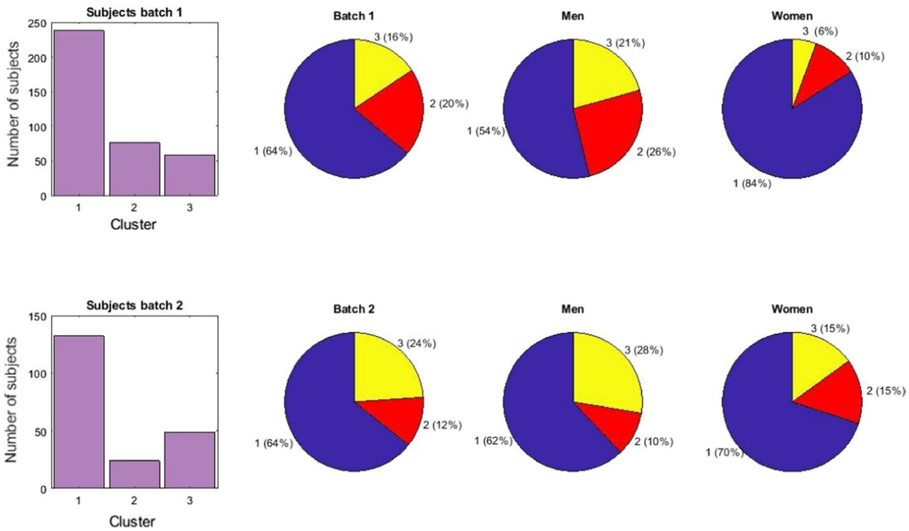


Fig. 9 Analysis of the clusters composition for students considering enrolling in engineering degrees

secondary students about studies and careers, as other previous studies found (López-Sáez, 1995, 2008).

The first specific objective of this work is to analyze the differences between boys and girls in the stereotyped perception of studies and degrees. The analysis of differences between boys and girls shows that boys have higher levels of stereotypes than girls. Higher percentages of boys perceive the studies associated to men or women, and lower percentage of boys perceive the studies in a neutral way. Girls have an equal perception of degrees, more equal than boys. These results are in accordance with Sánchez García et al. (2011) that showed a greater presence of gender stereotypes in men. The chi-squared test confirms that these differences depend on the sex of the student, with statistical significance in all studies except agronomy and aerospace engineering. Thus, gender stereotypes on studies follow linking the instrumental-agentic traits to men more than women (López-Sáez, 2008).

The second specific objective of the study is to analyze the differences in perception of stereotypes based on the intention to study a STEM career. The results obtained show that the intention to study engineering is not a relevant variable in the perception of stereotypes. Students who intend to study engineering have similar levels of stereotypes than students who don't want to. Moreover, in relation to the third specific objective, the analysis of stereotyped and neutral percentages of answers, and the clusters analysis, both indicate that there is a similar profile in the whole sample. However, the clusters composition for boys and girls show a polarization of results, because boys maintain their stereotyped view of studies, non-depending on their intention to study engineering; but girls change their perception. Girls who are not considering enrolling in engineering degrees have similar perception of stereotypes than boys, but girls with the intention to study engineering degrees show a more neutral view about gender and professions. In that case, results are according to Barth et al. (2015) where it is mentioned that women are less influenced by gender stereotypes when they are involved in STEM courses.

The analysis of the evolution of gender stereotypes associated with grades and professions is the last specific objective. The students of the second stage (2014–2017) show a more stereotyped perception of the careers related to STEM, compared to the students of the first stage (2008–2010). The results show a growth of the stereotyped perception that link the studies of Architecture, Informatics, Telecommunication, and Aerospace Engineering to men. These results can be found in both samples of boys and girls. Furthermore, girls show even higher levels of stereotypes than boys. It could be explained by the lower interest of women in courses related to computer science (Master et al., 2016; Stout et al., 2016). The analysis of the clusters offers similar results, because an increase in the extreme stereotype group is observed between both stages of the study.

Conclusions

The analysis of the gathered data confirmed that, as expected, the studies traditionally linked to the masculine role, such as technology, sports and engineering, are still considered more suitable for men than for women by boys and girls in secondary school. Moreover, studies related to feminine role, such as education, and psychology, are also considered more suitable for women than men. Then, traditional gender roles are still present and influencing the perception of secondary students about university studies, and future careers and professions. The stereotyped perception of careers may contribute to the horizontal discrimination that keeps women and men in differentiated working areas.

When data is analyzed taking into account the gender variable, boys show higher levels of stereotypes than girls and they assign technical studies to men. This finding is consistent with the results obtained by Sánchez García et al. (2011), in relation to the higher presence of gender stereotypes between men. The stereotyped perception of studies is one of the factors that influence the career choice.

The analysis of the time evolution of gender stereotypes in the last 10 years show a change of gender stereotypes perception in all groups in the sample. Contrary to the expected positive (less stereotyped) evolution of the stereotypes due to the amount of sensitization actions performed by governments and organizations, there is an intensification of the stereotyped perception of studies, and this intensification will be reflected in a future biased selection of university degrees. The evolution of gender stereotypes is more positive in boys than in girls. Boys show more stereotypes in two careers, Telecommunication and Aerospace Engineering; whereas girls show more stereotypes in Architecture, Informatics Engineering, Telecommunication, Aerospace Engineering, and Psychology. This rise in the presence of gender stereotypes between girls can explain the lower percentages of girls in technical studies. Actually, the presence of women in technical studies, engineering and architecture, is not increasing in Spain. The figures for female participation in these studies are stagnant, even slightly reduced. Percentage of women in Architecture and Engineering are: in 2010 there were 27.3% of girls in these degrees, while in 2016 the percentage had dropped to 25.6% (Ministry of Education, Culture and Sports, 2019).

Additionally, three different groups of behavior (clusters) have been detected in the data: one neutral (no stereotypes), another one slightly stereotyped, and another one strongly stereotyped. The general evolution of the number of subjects in each cluster leads to an increase in the extreme position (more people in the neutral or in the strong stereotypes cluster). Nevertheless, it is especially important that the total number of girls with stereotypes doubles from 16% in the first stage to 31% in the second analyzed period.

In summary, traditional gender roles are influencing the perception of secondary students about university studies, and boys show higher levels of stereotypes than girls. Additionally, three behaviors have been detected within the students (strong, slight and no stereotypes) and their evolution lead to an increase in the extreme positions that is especially important in the case of girls.

The scenario summarized above, in combination with the present situation that technical degrees involve mainly boys seems that, far from getting better, is going to be maintained or even increased in their masculine stereotype due to the perception of the boys and girls. Therefore, the actions performed by governments and organizations are not heading to a decrease in the engineering stereotypes. Girls are a minority of students in technical degrees, and this situation will remain for long time if more effective actions are not taken by universities, organizations and governments towards gender stereotypes changes.

The limitations of the study are that the sample belongs to the geographical area of the Valencian Community, so the study should be extended to a wider area at a national/international level and should be included more personal and social variables from the students.

Future work of this study will be to find a suitable explanation of the described situation. Understanding the reasons of this retrogression could give some hints towards the actions to be taken. The constant use of new technologies by adolescents can be an explanation of the increase of gender stereotypes. It is acknowledged that the mass media is one of the important factors for the transmission of gender stereotypes and roles. Nowadays, adolescents have broader access to contents available on the Internet, through devices such as mobile phones and tablets, which increase their exposure to the mass media. Therefore, an increase of influence (positive or negative) of the mass media can be expected. This hypothesis will be considered in future studies and its level of truthfulness confirmed.

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Data availability Data will not be shared because the belong to funding institution.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Consent to participate Participants in the study and their parents gave consent to participate.

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