

## **Engineering, a Course of Men: The Inversion of That Trend**

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## **Abstract**

Traditionally, engineering courses are more pursued by men than by women, although, also traditionally, there are exceptions, like for example Biological Engineering courses. In recent years, Higher Education in Portugal has faced profound changes, namely as far as the number of students, the enlargement of the educational network and the curricular structure of courses are concerned. It is known that the rise in the general number of students was also accompanied by an increase in the number of women attending Portuguese Higher Education Institutions.

This paper aims to analyze whether these changes have also changed the choice of women/men in engineering courses. Therefore, preferences and admissions from the last five years in fifteen engineering courses of a Portuguese University were analyzed.

This analysis aims at understanding if there are courses that tend to be more chosen by women, as well as the incidence of the Demand Satisfaction Index (here DSI) in their choices. The DSI is the ratio between the number of applicants in the 1<sup>st</sup> option and the number of existing vacancies per pair institution/ course, in the 1<sup>st</sup> phase of the national competition for higher education access.

For the academic years 2010/2011 to 2014/2015 we analyzed, for each course, the number of applicants and the number of students placed (by gender), the application option and the average grades of the admitted applicants. This analysis showed that the percentage of women has increased in both: in the number of applicants and in the number of admissions. The number of female applicants increased 4.7% in the general number of applicants for engineering courses and 3.4% in the number of female admitted students, among the total number of admissions, in the same period.

This convergence of the number of students of both genders contradicts the historical data, so it is important to understand its reasons. Therefore, each one of the courses was analyzed independently and we verify that in courses where the demand was already mainly female, that demand was further strengthened by women. In courses which have traditionally more male attendance, the percentage of women has been continuously approaching that of men. In conclusion, the conjunction of the growing attractiveness of engineering courses (which makes the admission more competitive) and the fact that, in general, women present better access grades to higher education is claimed as an explanation for this evolution.

## **Introduction**

In Portugal, higher education has undergone profound changes over the past 40 years, due to the enlargement of the educational network, the development of new educational institutions, an increase in the educational offer, as well as with the opening of the educational system to new publics. With the implementation of the Bologna process, European institutions tried to harmonize their degrees and education levels to enable the recognition of degrees, as well as the mobility of students among different countries and institutions. Therefore, it was decided to structure courses which grant an academic degree in three cycles of studies: the 1<sup>st</sup> cycle of studies granting a Bachelor's degree; the 2<sup>nd</sup> cycle of studies granting a master's degree; and the 3<sup>rd</sup> cycle of studies granting a doctorate's degree [1, 2, 3].

Concerning engineering courses, before the Bologna process, it took at least five years to achieve and grant a Bachelor's degree. After the implementation of the Bologna process and the European standardization, most engineering courses were structured in integrated cycles of studies, where the bachelor's degree and the master's degree are combined, keeping the need for a training period of five years [4, 5, 6, 7].

Aiming to understand whether the gender is a determinant factor, when it comes to choosing a course, an analysis of the national admission and entrance application in 15 higher education engineering courses, from 2010/2011 to 2014/2015, was carried out. The national admission and entrance application is currently the most common form of entrance [8].

The study had as object of analysis data concerning the admission and entrance application, in a public higher education institution, for registrations and admissions from 2010/2011 to 2014/2015.

The analyzed data concerns only the 1<sup>st</sup> phase of each admission application, since it is only possible to do a suitable comparison of the offer in this phase, looking at the vacancies and the demand of applicants [8, 9].

### **Higher Education: the representation of women in science and engineering**

The current existing dualism in science and engineering had its origin in the XVII century with Francis Bacon, who related science to the male gender and nature to the female gender. This dualism has been continuously influencing, up to the present days, the general perception of the world, which is reflected, among other aspects, in biased and stereotyped ways of conceiving what is professionally appropriate for each one of the genders and contributing for restraining, in the labor market, young and adult women to the repetition of those tasks which they have been doing in the private space [10, 11].

The European Commission defined, through the International Standard Classification of Education, eight broad fields of education, in which the courses shall be grouped: Education; Humanities and Arts; Social Science, Business and Law; Science, Maths and Informatics; Engineering, Manufacturing and Construction; Agriculture; Health and welfare; and Services [12].

Since our study focuses on 15 engineering courses, including Computer Engineering, we will evidence data concerning the fields of Science, Maths and Computer Science, as well as Engineering, Manufacturing and Construction; fields in which young and adult women have been encountering more difficulties in affirming themselves.

This is a common reality to most European countries, where in 2017 the proportion of women in Science and Engineering fields was 32% [13].

Therefore, in the field of Science, Mathematics and Computer Science are included the subfields of: (1) Life Science (Biology, Botanic, Biochemistry, Biophysics, among others); (2) Physics' Science (Chemistry Astronomy, geophysics; meteorology, among others); (3) Mathematics and statistics; and Computer Science (where software development is included) [14].

The field of Engineering, Manufacturing and Construction covers the subfields of: (1) Mechanical engineering; Electrotechnology, Electronics, Telecommunication; Chemistry and vehicles; (2) Manufacture and processing of food and beverages, textiles, leather, other materials, mines and extraction; and (3) Architecture and construction [14].

### Engineering in numbers

Taking into consideration the report of the Portuguese Higher Education Directorate [15], as well as the data from the Higher Education Institution used in our study, it is possible to infer the Portuguese reality through the data analysis.

Thus, considering the broad fields of Education and Training, we notice that in the field of Science, Mathematics and Computer Science, together with the field of Engineering, Manufacture and Construction have increased the number of numerus clausus (NC), both in terms of major groups and in terms of fields of study (Computer Science and Engineering and related technical fields) according to CNAEF (Classificação Nacional de Áreas de Educação e Formação) (Table 1) [15].

Table 1- NC in the Fields of Education and Training (CNAEF).

Fields of Education and Training (CNAEF)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Major Groups										
Science, Mathematics and Computer Science	4715	4795	4935	4489	4763	4565	4695	4884	4870	4939
Engineering, Manufacture and Construction	11480	11517	11740	11209	10999	11016	10817	11558	12217	12528
Fields of Study										
Computer Science	880	1070	1225	1049	1104	1027	1049	1107	1100	1136
Engineering and related Technical fields	7630	7612	7855	7456	7244	7273	7311	7822	8368	8690

As our study focuses on the options made by gender, during application and on admission, we present the percentage of demographic evolution of applicants and students admitted in the years mentioned by the report (Table 2) [15].

Table 2 - Demographic evolution of higher education applicants.

Gender		2001	2002	2003	2004	2005	2006	2007	2008	2009
Male	Applicants	39%	39%	40%	41%	38%	39%	41%	43%	43%
	Admitted	41%	41%	41%	42%	40%	40%	42%	43%	43%
Female	Applicants	61%	61%	60%	59%	62%	61%	59%	57%	57%
	Admitted	59%	59%	59%	58%	60%	60%	58%	57%	57%

Table 3 presents the data related to applicants admitted by field of Education and Training. As it can be verified, Engineering and related Technical fields is a field with a high admission rate, when compared to the remaining fields.

Table 3 – Applicants admitted in the Fields of Education and Training (CNAEF).

Fields of Education and Training (CNAEF)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Major Groups										
Science, Mathematics and Computer Science	3851	3270	3380	3181	3205	2945	3186	3819	4238	4207
Engineering, Manufacture and Construction	9027	7993	8772	8115	8545	6582	6435	9435	10948	10620
Fields of Study										
Computer Science	722	841	897	745	735	502	536	668	838	880
Engineering and related Technical fields	5815	5280	5792	5347	5500	4335	4160	6406	7592	7601

Table 4 shows the total number of students admitted to the the Higher Education Institution, which was object of study in this work and its DSI (Demand Satisfaction Index).

The DSI is an indicator of the demand for each of the training offers. It is defined by the ratio between the number of applicants who chose that specific offer as their first choice and the NC of that choice.

For ratios above 1, the demand is higher than the number of vacancies. Considering the values from 2000 to 2009 and comparing 2000 versus 2009, the Higher Education Institution, which was the target of this study, increased its DSI, as we can see in Table 4.

Table 4 – Total number of students admitted to the Higher Education Institution and its DSI.

Higher Education Institution	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
# students	2221	2306	2321	2191	2202	2212	2224	2397	2392	2392
DSI	1.16	1.08	1.03	0.95	0.89	0.98	0.95	1.42	1.43	1.36

## Methodology

The study analyzed all the applicants and students who were enrolled in 15 Engineering Courses of a Portuguese public Higher Education Institution, from 2010/2011 to 2014/2015.

With this study we aim to determine whether the gender influences the students' choice of the course in the Engineering field. Therefore, the number of applicants and admitted students were analyzed, as well as the DSI for each one of the courses involved in this study. A total of 15285 applicants were analyzed, 10665 are male and 4620 female. From the 3041 admitted applicants, 2101 are male and 940 are female. Simultaneously, the DSI of the assessed period was analyzed.

## Instruments and Procedures

The instruments used for this analysis were the corresponding files, for each course, of the 1<sup>st</sup> phase of the National Access Application, which is from the responsibility of the Higher Education General Directorate (DGES), a central Service of the Ministry of Education and Science (MEC), whose mission is to ensure the design, implementation and coordination of Higher Education policies.

These files contain several important data, in particular, the number of application's options and its corresponding percentage, the admission phase, the gender of applicants and admitted

students, the average grades of admitted students, the origin applicants and admitted students by district, and the 15 (fifteen) most frequent courses.

So, the number of applicants and admitted students were analyzed, by gender and school year, crosschecking the analysis with the DSI.

## Results analysis

The results presented in Table 5 show the percentages of applicants and admitted students by gender.

By analyzing the data, we can conclude that there has been an increase in the percentage of female applicants and admitted female students over the years. Regarding female applications, we notice that they fluctuate between 28, 4% and 33, 2%; while the percentage of female admitted students fluctuates between 29, 6% and 33%.

Concerning male applicants, and taking into account the timeline from 2010/2011 to 2014/2015, we notice that the number of male applicants decreased 4, 8%, while the number of male admitted students decreased 3, 4%, taking into account the same timeline.

Table 5 - Applicants and admitted students by gender (M/F) (%).

School Year	Applicants		Admitted	
	M	F	M	F
2010/2011	71,6%	28,4%	70,4%	29,6%
2011/2012	71,2%	28,8%	71%	29%
2012/2013	69,3%	30,7%	67,5%	32,5%
2013/2014	68,8%	31,2%	68,9%	31,1%
2014/2015	66,8%	33,2%	67%	33%

Table 6 shows the DSI number for each one of the 15 courses analyzed from 2010/2011 to 2014/2015.

Table 6 – DSI for courses analyzed.

Course	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
LEI/MIEI	1,00	1,20	1,26	1,68	1,29
LTSI/MIEGSI	0,82	0,4	0,94	0,8	0,65
LTSI/MIEGSI (PL)	0,25	0,12	0,07	0,03	0,02
MIEBiol	1,13	0,56	0,80	0,42	0,32
MIEBiom	1,50	1,48	1,32	1,26	1,44
MIEC	1,04	0,56	0,16	0,04	0,06
MIECom/MIETI	0,50	0,77	0,23	0,23	0,17
MIEEIC	1,54	1,00	0,78	0,44	0,36
MIEF	-	-	-	0,53	0,37
MIEGI	1,13	1,28	1,25	0,91	1,32
MIEMat	0,37	0,33	0,33	0,19	0,09
MIEMec	1,60	1,70	1,08	0,88	0,56
MIEP	0,53	0,43	0,29	0,06	0,19
MIET	0	0	-	-	-
MIET (PL)	0,07	0	-	-	-

It turns out that, in the period between 2010/2011 and 2014/2015, there are 21 DSI above 1, from which two of the courses, Bachelor's in Computer Engineering (LEI/MIEI) and the Integrated Master's in Biomedical Engineering (MIEBiom), present, in all the analyzed years, values above 1 in the DSI. The highest value presented in the DSI belongs to the Integrated Master course in Mechanical Engineering (MIEMec), in 2011/2012, with 1,7.

As 15 courses show an DSI value from 0,5 to 1, we decided not to analyze this group. Therefore, the focuses of this scientific study are the extremities, values above 1 and below 0,5 on the DSI.

From 2010/2011 to 2014/2015, there are 33 courses with values below 0,5. Three of these are present in all school years, namely, Bachelor's in Technologies and Information Systems/ Integrated Master's in Management and Information Systems (evening timetable) (LTSI/MIEGSI (PL)), Integrated Master's in Materials Engineering (MIEMat ) and Integrated Master's in Textile Engineering (evening timetable) (MIET (PL)).

In the academic years 2012/2013, 2013/2014 and 2014/2015, the values concerning the Integrated Master course in Textile Engineering (evening timetable) are not shown, since there were no students admitted in the 1st phase of the national admission application, from where this data was taken to analyze.

By analyzing the percentages of applicants and admitted students by gender, of the two courses which presented a constant DSI above 1, we note that 91% to 85% of the applicants and 90% to 87% of the admitted students of the Bachelor's in Computer engineering are male. In contrast, 61% to 68% of the applicants and 55% to 73% of the admitted students in the Integrated Master's in Biomedical Engineering are female.

The percentage of female applicants and admitted students has increased in both courses, in the Bachelor's in Computer Engineering and in the Integrated Master's in Biomedical Engineering (Table 7).

Table 7 - Applicants and admitted students in the Bachelor's in Computer Engineering (LEI/MIEI) and the Integrated Master's in Biomedical Engineering (MIEBiom) (%).

School Year	Course	Applicants		Admitted	
		M	F	M	F
2010/2011	LEI/MIEI	91%	9%	90,43%	9,57%
2010/2011	MIEBiom	38,98%	61,02%	45,10%	54,90%
2011/2012	LEI/MIEI	88,43%	11,57%	88,70%	11,30%
2011/2012	MIEBiom	37,30%	62,70%	28,00%	72,00%
2012/2013	LEI/MIEI	89,30%	10,70%	87,40%	12,60%
2012/2013	MIEBiom	40,89%	59,11%	54,00%	46,00%
2013/2014	LEI/MIEI	85,51%	14,49%	90,51%	9,49%
2013/2014	MIEBiom	32,87%	67,13%	30,65%	69,35%
2014/2015	LEI/MIEI	85,29%	14,71%	88,57%	11,43%
2014/2015	MIEBiom	31,90%	68,10%	26,56%	73,44%

In this analysis, it is possible to see that the male gender has a superior rate in all three courses, regarding applicants, even achieving the rate of 91,23% in 2010/2011.

As far as admitted students are concerned, there is a single value out of this axis of verification, since the Integrated Master's in Textile Engineering (evening timetable), in 2011/2012 shows that all admitted are female candidates, which distorts the results, therefore we decided to ignore this value (Table 8).

However, if we analyze the three courses within the timeline from 2010/2011 to 2014/2015, we note that the percentage of the female gender has been increasing over the years, reaching even parity in the Integrated Master's in Materials Engineering in 2013/2014 and 2014/2015 (Table 8).

Table 8 - Applicants and admitted students in the Bachelor's in Technologies and Information Systems/ Integrated Master's in Management and Information Systems (evening timetable) (LTSI/MIEGSI (PL)), Integrated Master's in Materials Engineering (MIEMat ) and Integrated Master's in Textile Engineering (evening timetable) (MIET (PL)) (%).

School Year	Course	Applicants		Admitted	
		M	F	M	F
2010/2011	LTSI/MIEGSI (PL)	91,23%	8,77%	100%	0%
2010/2011	MIEMat	63,16%	36,84%	60%	40%
2010/2011	MIET (PL)	69,70%	30,30%	75%	25%
2011/2012	LTSI/MIEGSI (PL)	86,05%	13,95%	85,71%	14,29%
2011/2012	MIEMat	66,88%	33,12%	70%	30%
2011/2012	MIET (PL)	58,82%	41,18%	0%	100%
2012/2013	LTSI/MIEGSI (PL)	81,82%	18,18%	90%	10%
2012/2013	MIEMat	61,82%	38,18%	60,87%	39,13%
2013/2014	LTSI/MIEGSI (PL)	87,18%	12,82%	86,67%	13,33%
2013/2014	MIEMat	63,29%	36,71%	50%	50%
2014/2015	LTSI/MIEGSI (PL)	76,92%	23,08%	75%	25%
2014/2015	MIEMat	53,70%	46,30%	50%	50%

## Conclusions

With this study, we verify that the percentage of the female gender students has increased, both in terms of applications and admissions in engineering courses in general, by academic year. This rate shows almost 5% increase in the number of applicants between 2010/2011 and 2014/2015, and effectively increases 3% in the number of admitted students, in the same academic years.

When comparing data obtained from applicants and admitted students in the 15 courses of the Higher Education Institution, which was object of study, grouped in the fields of Science, Mathematics and Computer Science, and in Engineering, Manufacture and Construction, we can conclude that the number of female students is becoming higher in the fields of Science, Mathematics and Computer Science.

When the courses with an DSI grater that 1 are analyzed, we verify that there are two cycles of studies that show this condition in the five academic years. However, they present opposed values what concerning the percentage of gender, since one of the courses is primarily a cycle of studies dominantly male and the other female. Nevertheless, both have increased the numbers of female applicants and the numbers of female admitted students.



Regarding the values below 0,5 presented in the DSI, 33 courses were analyzed, from which 3 of those courses are present in all school years. In this analysis group, the male gender is dominant in relation to the female gender.

However, the percentage of the female gender has also been increasing over these years, reaching even parity in one of the cycles of study.

Therefore, we can conclude that not only in terms of applicants but also in terms of admissions, the female gender has enlarged its space. So, we believe that Engineering has reversed the influence of male over female students.

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