A Quantitative Analysis of the Underrepresentation of Women in Science, Technology, Engineering, and Mathematics (STEM) Programs within Vocational Education and Training in Spain

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Abstract

The "leaky pipeline" metaphor describes the greater likelihood of women and girls to leave STEM fields at every point, relative to men and boys. Gender disparities occur both in recruitment—that is, who chooses to enter a STEM pathway—as well as retention—that is, who chooses to persist in a STEM major or occupation. In addition, women who persist in STEM careers are less likely than men to reach top levels of leadership in those careers.
Purpose: This paper describes and compares, in quantitative terms, female enrolment on STEM programs within Spain's vocational education and training (VET) system, analyzing the proportion both overall and by occupational group, while also examining the trend in these figures and the extent of progress.
Approach: Female enrolment on STEM programs in VET is analyzed at two distinct points: entry and completion. On the one hand, this paper analyzes the proportion of women entering STEM programs based on the number and distribution of women enrolling on STEM vocational education and training courses. On the other, it examines female representation among all holders of STEM qualifications, considering those graduates to represent the potential workforce leaving the education system. Moreover, its studies system efficiency in terms of course completion within the designated time, doing so via the completion rate.
Findings: This detailed quantitative breakdown by occupational group reveals a clear gender gap as regards female participation in STEM VET programs. Particularly noteworthy aspects of this difference between the genders are the low number of women attracted to these VET courses, the level of female representation across the STEM occupational groups and their completion rate at the end of the training and learning process.

Conclusions: It is important to note that the scarcity of studies of this issue in Spain, especially quantitative ones, shows the limited scientific attention paid to analyzing the gender gap in STEM subjects in the country's VET system. We therefore believe that this paper's innovative and socially relevant nature makes a valuable contribution to the field, since it represents one of the first steps towards employing scientific research into Spanish VET to help understand and characterize this field that is so important to achieving equality of opportunities for men and women and to advancing sustainable and resilient development in Spain. Finally, it is important to underline that this is an initial analysis of an area that will require further theoretical and empirical development in future years.

Keywords
vocational education and training, STEM, women

1 Introduction

The low proportion of women studying science, technology, engineering or mathematics (STEM) is a constant in secondary and tertiary education worldwide, even though various studies have demonstrated women's aptitude for those subjects (Buck et al., 2008; Christie et al., 2017). Women start to move away from STEM during compulsory secondary education, especially between the ages of 13 and 15 (National Centre for Education Statistics, 2013; OECD, 2017). This directly results in low numbers of women working in the traditionally male professions that generate greatest economic value (Struthers & Strachan, 2019). The scientific literature shows that this situation worsens at subsequent stages of education (post-compulsory secondary and university education), with the consequent underrepresentation of women in the labor market (Korbel, 2016; Makarem & Wan, 2020). Research conducted mainly at university level indicates that both female performance and retention (understood as women's choice to persist with the courses selected) in STEM subjects is similar to that of men. Thus, the underrepresentation of women is a consequence of low levels of enrolment in these disciplines and not of women's performance or aptitude (Diekman et al., 2015; Sadler et al., 2012).

This paper describes and compares, in quantitative terms, female enrolment on STEM programs within Spain's vocational education and training (VET) system, analyzing the proportion both overall and by occupational group, while also examining the trend in these figures and the extent of progress. Female enrolment on STEM courses in VET is analyzed at two distinct points: entry and completion. On the one hand, this paper analyzes the proportion of women entering STEM programs based on the number and distribution of women enrolling on STEM vocational education and training courses. On the other, it examines female representation among all holders of STEM qualifications, considering those graduates to represent the potential workforce leaving the education system. Moreover, its studies system efficiency in terms of course completion within the designated time, doing so via the completion rate.

2 Methodology

The methodology consists of conducting quantitative analysis of data gathered from secondary sources (Educabase, Spanish Ministry of Education and Vocational Education and Training [MEFP], etc.), analysing two academic years (2016/2017 and 2017/2018) taken from the latest figures available (Gamboa-Navarro et al., 2020; MEFP, 2020).

Firstly, we analyse female representation in STEM occupational groups in general and then examine those groups individually.

Secondly, we study female participation in Dual VET in STEM occupational groups.

Thirdly, we compare the completion rates of women in STEM occupational groups with those of men.

Fourthly, we analyse the employability of female STEM graduates in comparison with that of their male counterparts. This paper reports preliminary findings in these four areas.

Finally, we would like to point out, on the one hand, that this study is novel in the Spanish context and, on the other, that it is relevant given the underrepresentation of women on STEM programs in VET, a situation that creates barriers both to women's professional development and Spain's economic and social advancement. This is both because employability in these occupational groups is usually higher than in the rest and because of the amount of value these occupational groups generate for enterprises. Studying the proportion of women on STEM programs in VET is key to examining their underrepresentation in detail and so advancing our understanding of a significant problem for Spanish society, thereby allowing for reflection on possible ways of encouraging female participation in these occupational groups.

3   Results and Discussion

In our initial analysis of the data on the proportion of women enrolled in VET programs providing access to the STEM occupational groups, it is first important to determine the number of VET students taking STEM qualifications.

3.1   Female Access to VET in STEM Occupational Groups

The figures in Spain, which have remained stable in the last two academic years for which data are available, show that around 36% of the 815,354 students are enrolled in STEM programs and that roughly only one in ten (11.5%) of those students is female.

Moreover, based on the figures in Table 1 below, the breakdown by level of education of the women on VET courses in the STEM occupational groups shows several major imbalances. Overall, 61.9% are on Higher VET programs, with 29.2% studying Intermediate VET courses and just 8.9% enrolled in Basic VET.

Table 1
Female enrolment in VET and STEM-based VET by level of education (2016/2017 and 2017/2018 academic years)

		2016/2017	2017/2018
Total VET enrolment	n	791,385	815,354
Total STEM VET enrolment	n	290,224	296,144
	%	36.7%	36.3%
Total female STEM VET enrolment	n	33,263	34,063
	%	11.5%	11.5%
Total female enrolment in Higher STEM VET (% of total women enrolled in STEM VET)	n	20,619	21,074
	%	62.0%	61.9%
Total female enrolment in Intermediate STEM VET (% of total women enrolled in STEM VET)	n	9,744	9,942
	%	29.3%	29.2%
Total female enrolment in Basic STEM VET (% of total women enrolled in STEM VET)	n	2,900	3,047
	%	8.7%	8.9%

Source: Compiled in-house from Educabase data provided by the MEFP (2021)

Analysis of the breakdown of female enrolment by STEM occupational group reveals a heterogeneous distribution across the different groups (Table 2). Of the total number of women (34,063) who took these courses in the 2017/2018 academic year, most were found in just one third of the STEM occupational groups available. Consequently, three out of every four women were enrolled in one of four occupational groups. The most popular occupational group among

the total number of women enrolled in STEM programs was IT and Communications (29.3%). It was followed by Image and Sound (17.9%), Chemistry (15.6%) and Food Industries (10.8%). Of these four occupational groups, only IT and Communications is among the five programs with greatest overall demand (91,59%), reducing the absolute number of female VET students in STEM occupational groups.

Another aspect worth highlighting is the proportion of female students in each of the STEM occupational groups, which is also shown in Table 2. The distribution is not uniform in this case either. At one extreme, we see predominantly female STEM occupational groups in which 50% or more of enrolees are women, as in the case of Chemistry (51.8%) and Food Industries (50.8%). At the other, we find occupational groups with minimal female presence and evident male predominance: Transport and Vehicle Maintenance (2.8%), Electricity and Electronics (3.8%) and Machine Manufacture (5.4%).

Table 2

Enrolment in STEM occupational groups (2017/2018 academic year)

	Total STEM VET students	% of total women enrolled in STEM VET		Women as % of total students in each occupational group
	n	n	%	%
IT and Communications	91,595	9,984	29.3%	10.9%
Electricity and Electronics	59,085	2,254	6.6%	3.8%
Transport and Vehicle Maintenance	45,528	1,273	3.7%	2.8%
Machine Manufacture	26,235	1,415	4.2%	5.4%
Installation and Maintenance	24,221	1,930	5.7%	8.0%
Image and Sound	19,841	6,084	17.9%	30.7%
Chemistry	10,231	5.303	15.6%	51.8%
Food Industries	7,234	3,676	10.8%	50.8%
Building and Civil Works	5,282	1,403	4.1%	26.6%
Wood, Furniture and Cork	4,842	567	1.7%	11.7%
Energy and Water	2,050	174	0.5%	8.5%
Total STEM VET	296,144	34,063	100%	11.5%

Source: Compiled in-house from Educabase data provided by the MEFP (2021)

Analyzing the data in greater detail, we now focus on Dual VET, which is an alternance training model that combines classroom teaching at VET schools with on-the-job learning, usually in firms. Table 3 shows that in this VET option the STEM occupational groups accounted for a greater proportion of enrolment (45%) than they did in non-Dual VET programs (36.3% – Table 1) in the 2017/2018 academic year. Nevertheless, female representation in the STEM occupational groups remained very low, around 11%, similar to the situation with non-Dual VET STEM courses.

Therefore, although Dual VET does not penalize women, neither in general terms does it encourage greater female participation. Breaking down the overall figure by level of education reveals that the highest proportion of women are enrolled in the highest level (i.e. Higher VET, ISCED 5). The pattern of distribution according to level of education seen in VET is repeated in Dual VET in the STEM occupational groups, where female participation is greatest in Higher Dual VET (69.7%), followed by Intermediate Dual VET (23.9%) and Basic Dual VET (6.4%).

Table 3

Enrolment in Dual VET and Dual STEM-based VET by level of education (2016/2017 and 2017/2018 academic years)

		2016/2017	2017/2018
Total Dual VET enrolment	n	19,943	22,616
Total Dual STEM VET enrolment	n	8,538	10,167
	%	42.8%	45.0%
Total female enrolment in Dual STEM VET	n	962	1,164
	%	11.3%	11.4%
Female enrolment in Higher Dual STEM VET (% of total women enrolled in Dual STEM VET)	n	733	811
	%	76.2%	69.7%
Female enrolment in Intermediate Dual STEM VET (% of total women enrolled in Dual STEM VET)	n	229	278
	%	23.8%	23.9%
Female enrolment in Basic Dual STEM VET	n	-	75
(% of total women enrolled in Dual STEM VET)		-	6.4%

Source: Compiled in-house from Educabase data provided by the MEFP (2021)

3.2 Efficiency of the Education and Training Process

Another key indicator when analyzing the situation regarding female VET students in the STEM occupational groups is provided by the completion rate. While the enrolment rate indicates the attraction to these studies have for women and their level of participation in them, the completion rate shows how efficient the education and training process is for female students. This indicator refers to the percentage of students who complete their studies in a given academic year out of the total number of students enrolled in the first year of each course in the previous academic year. The number of first-year students is obtained by dividing the number of students in the academic year of interest by two so as to calculate the completion rates for the greatest possible number of academic years, given that the figures for VET students by year (first and second year) are only available in the source data for the 2016/2017 and 2017/2018 academic years.

The first finding that stands out is that students in the STEM occupational groups had lower completion rates (53.8%) than the overall VET average (61.6%) in the 2017/2018 academic year. The second finding is that the level of education and the completion rate are directly linked; in other words, the higher the level of education, the higher the success rate. Thus, the figure for Higher VET rises to 56.7% compared to approximately 52% for Basic and Intermediate VET also in the 2017/2018 academic year.

Finally, we found that in the last academic year for which data are available the female completion rate was 6 points lower than the male one in the STEM occupational groups. This situation requires further analysis because the reasons for this lower performance could be the consequence of circumstances prior to entering VET, or of issues associated with the VET process itself over the course of each 2-year program.

Table 4

Comparison of completion rates: Completion rate over two academic years (2016/2017 and 2017/2018)

	2016/2017	2017/2018
Total VET completion rate	60.2%	61.6%
Total STEM completion rate	53.1%	53.8%
Higher STEM VET completion rate	56.7%	56.7%
Intermediate STEM VET completion rate	49.3%	51.2%
Basic STEM VET completion rate	54.7%	52.2%
STEM VET completion rate (female total)	48.0%	51.6%
STEM VET completion rate (male total)	53.7%	57.9%

Source: Compiled in-house from Educabase data provided by the MEFP (2021)

3.3 Employability of Female Graduates in STEM Occupational Groups

The next steps in the analysis aim to shed light on the employability of female STEM VET graduates. To this end, we use three employment-related indicators: the labor force participation rate, the employment rate and the unemployment rate.

As can be seen in Table 5, the labor force participation rate and the employment rate show more favorable outcomes for female graduates with STEM qualifications in comparison to those with non-STEM ones. In this regard, labor force participation among women with a STEM qualification is above both the total female rate and the average for women with qualifications in non-STEM occupational groups in Higher VET. Employment rates are also better among those women who studied Higher VET in comparison to both the total female rate and the average for women with qualifications in non-STEM occupational groups.

Regarding the unemployment indicator, the figures also show a benefit for Intermediate and Higher VET graduates with STEM qualifications, as in both cases the unemployment rate is below both the average and the figure for women who did not study in STEM occupational groups.

The above make evident that STEM courses make VET graduates more employable, and the fact that women are a minority in both access to the programs and graduation from them (11%) places women at a disadvantage when it comes to seizing employment opportunities. The fact that most of Spain's female VET students and graduates do not choose STEM subjects constitutes a major disadvantage as regards their future employability in a labor market that rewards candidates with a scientific-technical VET background. It is therefore imperative that public policy decisions and measures be implemented to address this.

Table 5

Employment status in 2019 of female Intermediate and Higher VET graduates

(2013/2014 academic year)	Labor force participation rate			Employment rate			Unemployment rate		
	STEM	non-STEM	Total women	STEM	non-STEM	Total women	STEM	non-STEM	Total women
Intermediate VET	87.1	87.1	88.0	71.2	67.6	71.6	18.0	22.4	18.7
Higher VET	90.5	89.7	89.9	78.7	74.5	77.1	13.0	17.1	14.3

Source: Compiled in-house from the 2019 INE survey on the transition from education–training to employment (Instituto Nacional de Estadística [INE], 2021).
Note: The STEM and non-STEM rates have been calculated as average rates in the relevant occupational groups.

Finally, we supplement our analysis by applying the same labor market indicators to male VET graduates with STEM qualifications (Table 6).

In this regard, labor force participation and employment rates among men with a STEM qualification is above the STEM female average Meanwhile, unemployment rates are also better among those men who studied Higher STEM VET than among women.

When we apply the same indicators linked to male employment to the analysis, the trend shows the same pattern seen above with women. Thus, the labor force participation rate and employment rate are higher among VET graduates in STEM occupational groups and the unemployment rate is lower. However, when we compare the scale of the advantage — in terms of the labor force participation and employment rates — among men studying STEM subjects in VET as compared to the overall male, or as compared to men average without VET qualifications in STEM subjects, we see that the difference is greater than that observed among women. In contrast, the difference in unemployment rates favors female VET graduates with STEM qualifications in a greater extent as compared to those who took non-STEM VET.

Table 6
Employment status in 2019 of male Intermediate and Higher VET graduates (2013/2014 academic year)

	Labor force participation rate			Employment rate			Unemployment rate		
	STEM	non-STEM	Total men	STEM	non-STEM	Total men	STEM	non-STEM	Total men
Intermediate VET	90.2	89.5	89.6	77.7	74.6	77.5	14.0	16.7	13.5
Higher VET	93.6	91.5	91.9	84.2	79.1	82.0	10.0	13.5	10.9

Source: Compiled in-house from the 2019 INE survey on the transition from education–training to employment (Instituto Nacional de Estadística [INE], 2021)
Note: The STEM and non-STEM rates have been calculated as average rates in the relevant occupational groups.

4   Conclusions

As a starting point for the conclusions, it is important to note that this research remains ongoing and that the conclusions are subject to change once the project is completed.

Firstly, the authors substantiate the underrepresentation of women on STEM programs in VET in Spain. Of the total number of VET students enrolled in the 2017/2018 academic year, 36% were studying STEM subjects, of which 11.4% were women. Furthermore, while the number of these enrollees has fallen by almost two percentage points since 2012/2013, underrepresentation has increased in relative terms in the last five years.

Secondly, female underrepresentation in entry to STEM programs (11.4%), in terms of number of enrolments, is matched by the proportion (11%) of total STEM graduates in the 2016/2017 and 2017/2018 academic years. However, in the last academic year for which data are available the female completion rate was 6 points lower than the male one in the STEM occupational groups. This situation requires further analysis because the reasons for this lower performance could be the consequence of circumstances prior to entering VET, or of issues associated with the VET process itself over the course of each 2-year program.

Thirdly, female representation is unequal between STEM occupational groups, ranging from over 50% in the case of Chemistry and Food Industries to less than 5% in Electricity and Electronics, Installation and Maintenance, and Vehicle Maintenance and Transport. However, most job offers target these latter occupational groups (Infoempleo-Adecco, 2020). Therefore, analysis of female representation by occupational group needs to be conducted at the level of each group, or in even greater detail at program level.

Fourthly, female underrepresentation in STEM in Dual VET is increasing, meaning that the effort to raise their participation in Dual VET associated with the STEM occupational groups needs to be greater.

Fifthly, female STEM graduates show better employment outcomes than those who do not follow STEM courses. However, labor market rewards are greater for male STEM graduates than for females. These differences in labor market outcomes may be due to employers' gender stereotypes, which should be explored in greater depth in future research.

Finally, this area of knowledge requires greater analysis given the limited and fragmented research conducted to date.

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