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Women in STEM
From Basic education to Professional Careers

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Key Data

This study proposes the deepest and most detailed analysis of gender inequality in STEM fields in Spain to date. Distinctively, we put the focus on the areas with the greatest weight of mathematics, the area where the most pronounced gaps occur; we cover from basic education, thanks to the latest PISA results, to working careers, for which we create new indicators. In addition, we use innovative data combined with economic evidence of the highest quality.

Basic Education

The difference between genders in the STEM fields begins to manifest itself at an early age in mathematics results, specifically in primary education. This is evidenced by lower self-confidence, higher math anxiety and emotional distress in girls, leading to lower math scores.

Thanks to an exhaustive and unprecedented analysis of the data from PISA 2022 and previous editions, we observe that:

→ At age 15, this gap continues, although it has decreased by 37.5% since 2012. The gap does not exist among students with lower grades, but it does exist among the rest.

→ The gap is significant in all mathematical content assessed, being more pronounced in the ability to identify and formulate problems.

Accumulating evidence indicates that these differences in outcomes vary by affect, self-perception, and math anxiety.

→ **Self-perception and affect:** already in 4th grade of elementary education girls are 15% less likely than boys to consider mathematics as their favorite subject, and 8-9% less likely to consider themselves good at it, learn quickly, or enjoy it. They are more likely to think it is boring and difficult, although they are more likely to devote time or effort to it. In contrast, they are more likely to lose interest or drop out when they do not understand the subject.

→ **Anxiety: at 15, girls are substantially more likely than boys (21%) to report feeling nervous or hopeless when solving math problems, as well as worrying about low grades. Moreover, these figures are worse in 2022 than they were a decade ago.**

→ All these markers have a significant relationship with math scores: **negative self-perception correlates downward, while affect correlates upward.**

Chosen education: High School, University and Vocational training

Expectations translate into choices from the moment they become available to girls and boys, as we observed by collecting, completing and expanding the existing evidence in this regard:

→ In High school, the presence of girls in the scientific-technical branches is consistently lower, despite the fact that the percentage that successfully complete their studies is higher than that of boys.

→ Something similar happens with university entrance exams, in which girls less frequently choose subjects such as Physics (x2.65) or Technical Drawing (x2.13), despite obtaining identical or slightly higher grades in access to careers that require them.

→ The next step is that **the rates of women out of the total number of people enrolled in STEM university degrees does not reach 50% in almost any case**, and in Mathematics (36%), Physics (27%), Telecommunications (23%), or Computer Science (13%) are especially low.

→ In addition, the presence has also decreased in absolute terms: in Mathematics it was 51% in 1990; 6,257 women, vs. 4,836 now. In Physics, 5,074 (31%) compared to 3,171. And in Computer Science it reached 16,900 in the year 2000 (21%), not reaching 5,000 in 2020.

→ The pattern is reproduced in postgraduate programs: 31% enrolled in Engineering and Construction masters, 25.5% in Mathematics and Statistics, and not even 23% in Computer Science.

→ And in Vocational Education the gap is even deeper: out of all male VET graduates, 52% are in STEM fields; compared to only 7% of women. In most STEM degrees, both middle and higher, the male/female ratio is practically 9 to 1.

The gender gap in STEM occupations

Early-stage data anticipate that the gaps carry over into the working career: the probability of aspiring at age fifteen to have a STEM profession at age 30 is 12.7% lower for girls than for boys, a gap that does not vary when taking into account the level of achievement.

Thanks to the development of a novel indicator, we can gauge the real presence of women in STEM occupations:

→ The percentage of women in a STEM occupation out of the total number of women employed in Spain at the end of 2022 is 5.5%. In men, that figure reaches 13%, so the ratio is x2.4 in favor of men. The rate for women has increased substantially since 2011, when it was 3.3%.

→ Among those under 30 years of age, women in STEM occupations reach 9%, to drop to 7% among those aged 30 to 44. Also, the improvement since 2011 is greater among the youngest.

→ If the total number of STEM positions is divided by gender, only 1 in 4 is held by a woman, a proportion that has remained constant since 2011.

→ By sector, STEM occupations that have lowest female presence are construction (18%) and information and communications (23%).

All of this suggests that the fact that a woman is trained in these fields does not necessarily translate into being employed in them.

→ Our analysis indicates that women who have completed a STEM degree are, 5 years later, around 2.7% less likely to work in a STEM occupation than their male counterparts.

This underrepresentation in STEM fields implies less access for women to what evidence indicates are better working conditions:

→ In Spain, women in professional or technical STEM occupations face a wage gap significantly lower than average, and notably lower than their equivalents in non-STEM fields.

→ At the same time, women employed in a STEM field are less likely to end up in part-time employment.

Ideas and proposals

Curricular rigidity, lack of pedagogical tools, and insufficient reinforcement, accompaniment and guidance are structural problems of our educational system that deepen situations of disadvantage at the outset. Tackling them would benefit equal opportunities, including improving the participation of female students in STEM subjects:

→ **Encourage participation in STEM areas through courses, extracurricular** or summer activities, also seeking to activate mechanisms of self-confidence, self-perception and affection towards mathematics.

→ **→ Eliminate biases in the curriculum and materials,** making them more flexible and adaptable to the needs of all students, achieving more inclusive educational models and content.

→ **Provide teachers with teaching tools** to provide STEM education that minimizes bias, is inclusive, more individualized, dynamic, with collaborative scientific-mathematical problem solving.

→ **Provide individualized guidance** to support decision making and ensure that no one neglects a potential choice to undertake STEM training for lack of appropriate guidance at the right time.

In addition, more specifically, we propose::

→ **Raise awareness among families**, increasing exposure to mathematical concepts at home from early ages and promoting parental involvement in the mathematics learning processes.

→ **Increase girls' access a**t crucial decision-making moments **to** *role models* **through mentoring, master classes, or other forms of direct access** to women currently in STEM positions.

→ **Incentivize access** to *bootcamps*, intensive training programs to acquire specific STEM skills.

In the labor field, we suggest:

→ **Fostering an inclusive work environment,** changing younger people's view of STEM occupations and reducing the dropout of women already in these careers.

→ **Ensure policies that support equal opportunity access** to STEM careers, with co-responsible work-life balance for men and women, equitable pay and promotion, and well-specified standards.

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Why this report

The gender gap in scientific-technical fields is a fact apparently worked on in Spain, both by academic research (Sánchez-Mangas and Sánchez- Marcos, 2021) and by reports from public (Sillero and Gómez, 2019) or private (ClosinGap Index, PwC) institutions. These efforts are motivated by the concern of unequal representation in these areas. With this paper we intend to **contribute in a distinctive way to dimension, in a descriptive way, to what degree this inequality between women and men exists, when, where and how it occurs.** The distinctiveness of our contribution is given by three aspects that also motivate in themselves the realization of this work: a strict focus on STEM (science-technology-engineering-mathematics) with a mathematical-quantitative basis, a comprehensive perspective from childhood to the working careers of women, and the use of the best available data and evidence to answer these questions.

The first of the defining elements of this paper is a **delimitation** of what deserves special attention as part of the STEM field. We propose here a precise focus starting with **mathematics and the use of quantitative tools as a central and transversal component of everything that falls within the STEM field.** On the one hand, because it is its main differentiating feature compared to other areas of knowledge and skills. On the other hand, because it is in this trait that the greatest potential added value for the economy and society as a whole seems to reside, and at the same time the one that concentrates the most barriers for girls from an early age and for women as they advance in their educational and labor journey.

To this essential component we add three, considering that the presence of any of them by themselves, accompanied by the mathematical-quantitative load, imply that a knowledge or profession falls within our scope of analytical interest: scientific approach (following the scientific method of empirical hypothesis testing), engineering (focused on problem solutions seeking maximum efficiency), or technical (focused on the implementation of all of the above). This approach complements existing work, as this is not a study of gaps in scientific research in any field, nor in a specific sector or group of sectors. This distinctive approach allows us to address how and to what extent gender gaps operate in booming areas (Cedefop, 2015; UNESCO, 2021) that also offer better working conditions (Joensen and Nielsen, 2016; ILO, 2019). **It is also in these segments where**, as will be seen in our analysis, a **larger gap in female representation can be seen, which helps to cement our bounding.**

The second is a perspective that is as complete and cohesive as possible, **starting in basic education and ending in developed careers.** Once we have defined our analytical center of gravity (i.e., narrowed STEM), we can identify how gender gaps operate at each stage of life. We can do so in a multifaceted way, looking not only at performance but also at perceptions or choices, at occupations, but also at labor market outcomes, honoring the complexity of the issue at hand. It is worth mentioning that, to carry out an exercise of greater analytical precision that would minimize the use of different sources and allow us to understand, with the greatest rigor, the evolution of the gaps throughout life, would require on the one hand to have more precise administrative information on occupations and sectors -which is not available due to anonymization- and administrative databases that would unify the different educational stages and the working lives of men and women.

The third distinctive element is the **demand for rigor and novelty**, which we hope will contribute to expanding and improving the work already done. This requirement has two aspects. On the one hand, it implies choosing the indicators that are most refined and adjusted to the phenomenon as we have delimited it. This makes us innovate in the selection of some statistical sources or in the way of approaching those that have already become a landscape in this type of report.

- For **educational stages**, we provide the most recent descriptive evidence on gender gaps in mathematics achievement and the underlying causes and consequences of these gaps.

- With respect to **labor market gaps**, in order to avoid straying down analytical paths that are too narrow (science only, or digital/ICT only) or overly broad (selecting as STEM any type of discipline or occupation involving higher education) we classify occupations and sectors of STEM fields as rigorously as the data allow.

On the other hand, we translate the self-demand not only by turning to the best data that, as far as we know, exist for Spain, **but also to the highest quality scientific evidence that allows us to contextualize them**: motivating our approaches, providing explanatory support for our results, or guiding our proposals. By "quality" we understand evidence that offers high confidence of causal identification (experimental or quasi-experimental methods), faithfully representative data and at least partially extrapolable contexts. Whenever possible, we prioritize this evidence over others, and show it to complete our analyses.

Counting with all these instruments, we try to produce here a chronological vision that leads to proposals for action. In the first section we explore in depth how the gap begins to manifest itself from an early age, evidenced in lower self-confidence, greater anxiety towards mathematics and emotional affectation in girls, leading to lower results in this subject. Over time, and moving on to the next section, this gap instead of narrowing widens, reflected in a lower choice of STEM studies by girls in college and vocational training, despite having similar educational outcomes. This lower female presence in STEM fields and preferences already formed since adolescence impacts, as we will see in the section that follows, on the labor market, translating into reduced participation in jobs and sectors related to these areas. In the final section we seek to present concrete and accessible proposals, chosen based on evidence showing their effects, to break this cycle that not only limits women's job opportunities in sectors with good conditions, but also deprives society of role models that could inspire future generations

Basic education: starting point

The debate on differential academic performance between boys and girls depending on the field of study has been the subject of extensive debate for decades. Data from international tests in both Primary and Compulsory Secondary Education (ESO) leave no room for doubt: girls perform better in reading and boys in mathematics and, although these differences have varied over time, they remain significant throughout basic education. In this first section we carry out an in-depth analysis based on the existing standard tests, with a special focus on the data from the latest wave of PISA in 2022, which has not been explored (to our knowledge) in this regard, and its comparison with previous years.

According to the latest available data (PIRLS, 2021) for **reading tests, girls already outperform boys at the age of ten in all participating EU27 countries, except in Spain**, the Czech Republic and Malta, where the differences are positive in favor of girls but not statistically significant. On the contrary, **in mathematics girls obtain lower results in all participating EU1, including Spain, which is, in fact, the third country in the Union with the largest differences in performance, only below Cyprus and Portugal (TIMSS, 2019).**

age 15, the PISA'22 international test provides results that point in the same direction: in reading, girls perform better than boys in all EU27 countries, with Spain slightly below the average (27 gap points[2]), while in mathematics girls perform worse in all countries[3], with Spain above the average and Italy in the lead.

Differences in mathematics performance

In Spain, there is a gender gap in mathematics achievement as early as 4th grade of primary school, and this gap has grown in recent years. At this age, the greatest differences are found for the highest grades. It is the Trends in International Mathematics and Science Study (TIMSS) that allows us to delve into these gender differences in mathematics for Spain in 4th grade of Primary Education. These tests reveal not only that the gap continues to exist, but that it has increased from 11.1 points in 2011 to 14.6 in 2019 (last year with available data). Looking at the distribution by levels in mathematics, the pattern points to a higher concentration of girls at the low level (37.3% vs. 30.3%) and a lower concentration at the high level (21.3% vs. 31.2%), with the differences being smaller for the middle levels of grades (41.4% of girls vs. 37.3% of boys).

The average score in mathematical competence at age 15 has declined in the last decade for both boys and girls, with the drop for the former being substantially greater (14 points versus 7). In addition, the gender gap has decreased — although irregularly — but, it persists in the middle and high performance levels. The Program for International Student Assessment (PISA), carried out by students at the age of 15 —regardless of the year they are in — in all the autonomous communities, points in the same direction: in Spain,

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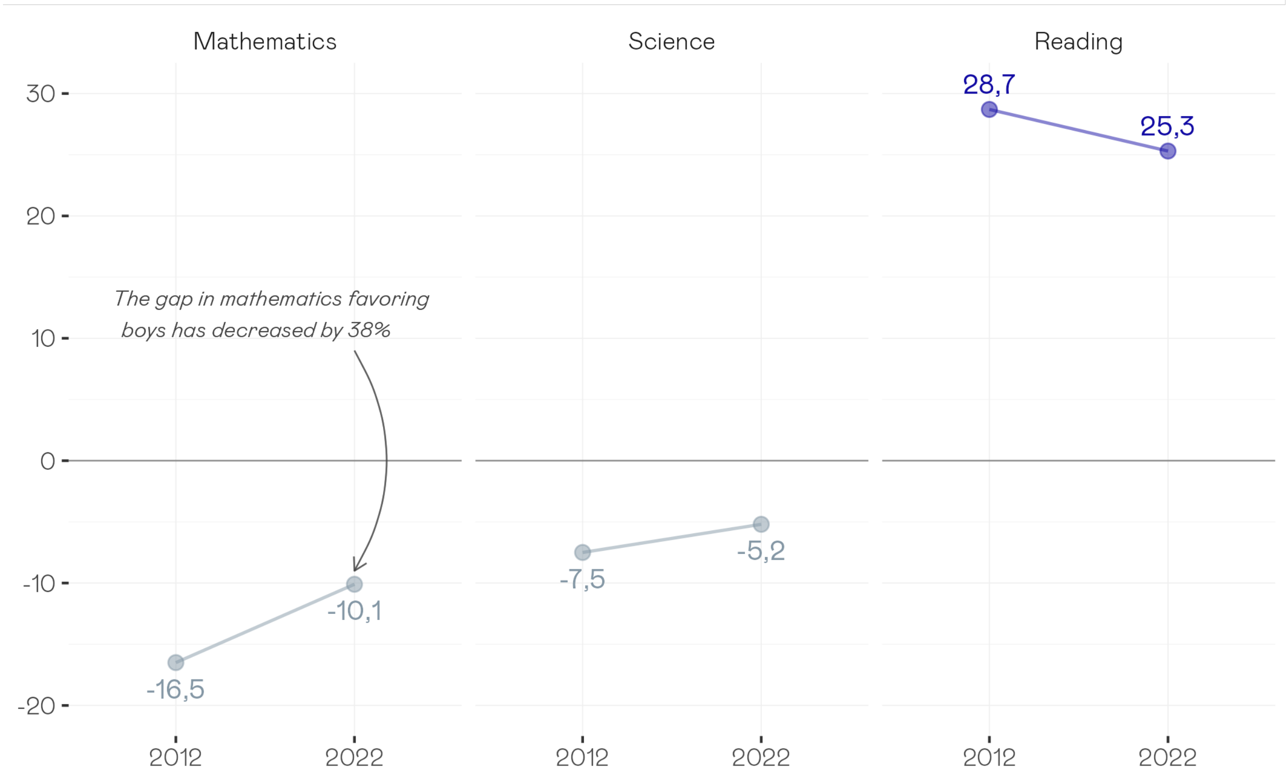
[1] In five of these countries the differences are not statistically significant.

[2] Scores in both TIMSS and PIRLS as well as PISA are out of 500 points.

[3] In Malta, Slovakia, Slovenia and Sweden the differences are not statistically significant.

girls of that age obtain worse results than boys in mathematics; especifically, 10 points less[4], a difference that, although it is true that it has decreased over the last decade — as in scientific and reading competency —(see Figure 1), has done so in a certainly irregular manner (Figure 2).

Figure 1. **Evolution of the gap in PISA scores in favor of boys or girls.**



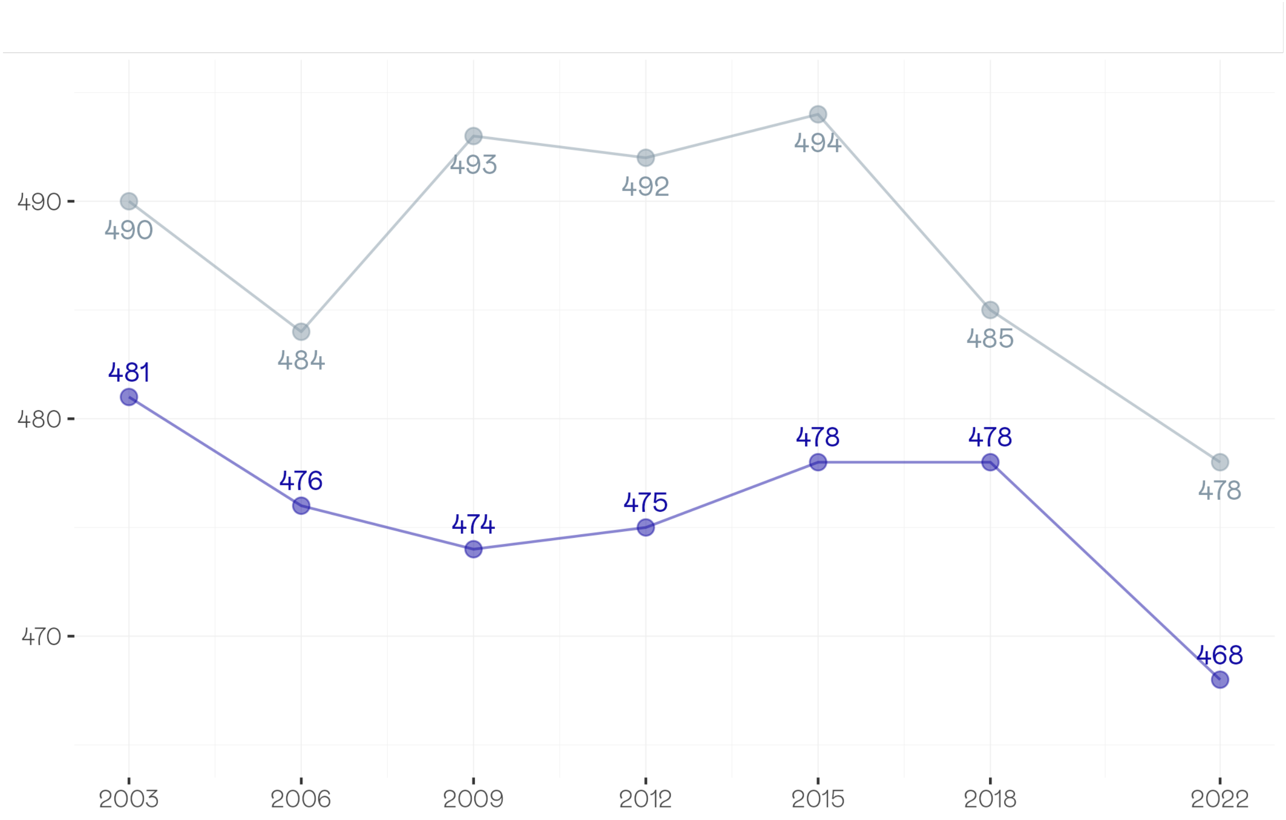
Source: PISA (2012, 2022) | EsadeEcPol

This gap is observed at the median performance and at the highest levels and has narrowed at both levels during the last decade. However, there are no relevant gender differences at the lowest levels of performance[5].

[4] The results between TIMSS and PISA are not strictly comparable despite having a similar structure and, therefore, comparisons should not be made between the results at these two educational stages.

[5] High level in PISA equals a level greater than or equal to 5 (more than 605 points); low level in PISA equals a level less than or equal to 2 (less than 420 points).

Figure 2. **Evolution of girls and boys in mathematics scores**

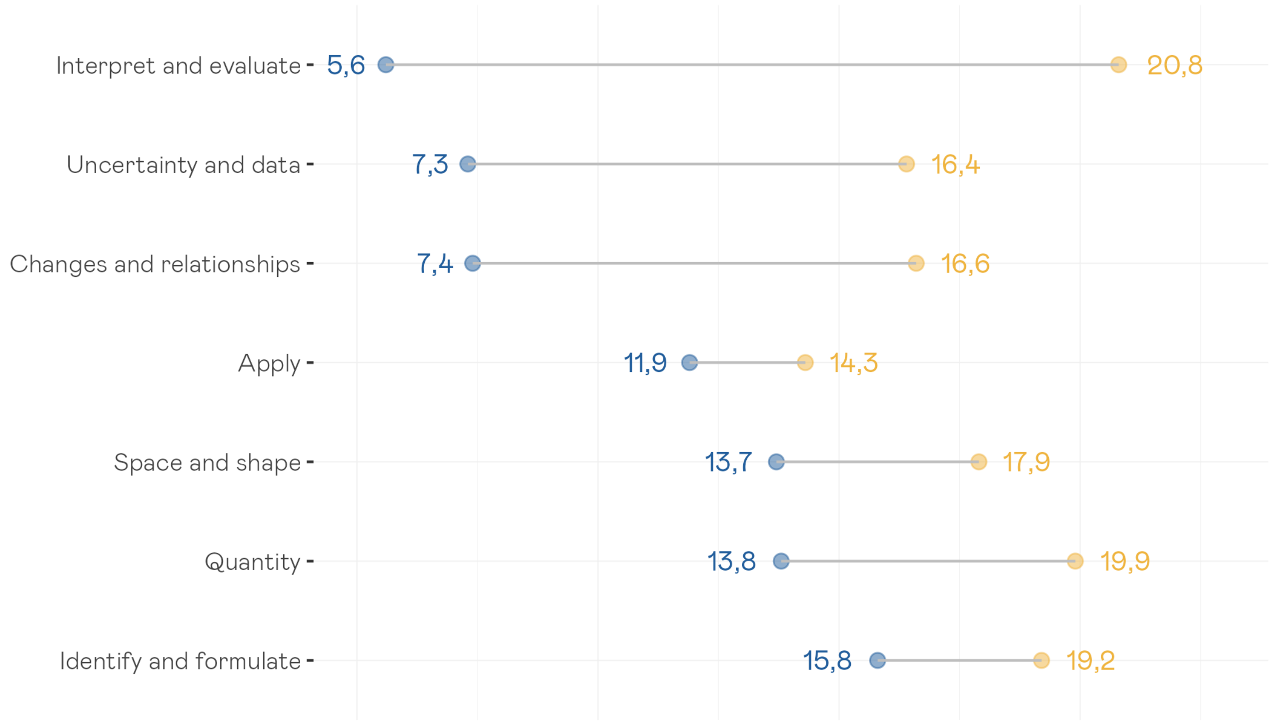


Source: PISA (2012, 2022) | EsadeEcPol

The gender gap in mathematics exists and is significant in all mathematical processes and components, being especially pronounced in the ability to identify and formulate problems. The PISA data allow us to delve deeper, with a sufficient sample, into the different components of the mathematics exams, to observe in what kind of processes (identifying and formulating problems, questions of space and shape, quantity questions, etc.) the gap is more or less pronounced (Figure 3). The differences exist and are statistically significant in all of them, but especially in the ability to identify and formulate, and in the knowledge of quantity, as well as of space and shape. But it has also been reduced in all of them. Particularly striking is the relative closing of the gender gap in the ability to interpret and evaluate: while in 2012 boys scored 20.8 points higher than girls in this key competency, in 2022 the difference is 5.6 points, the lowest in components and processes[6].

[6] The RIF-Oaxaca decomposition to understand the contribution of each component and process to the drop in the average score over the last decade sheds some more light: the largest drop in girls is due to the ability to "employ" (26%), while in the case of boys, it is due to the ability to interpret and evaluate. In any case, the gender differences in the contribution to the drop are not too pronounced.

Figure 3. **Gap reduction in favor of boys versus girls in PISA math scores** · between 2012 and 2022



Source: PISA (2012, 2022) | EsadeEcPol

There is no robust evidence for Spain as a whole on the evolution of the gender gap in mathematics throughout compulsory education. However, the literature and a case study for Madrid point to an increase from 3rd grade of primary education to 4th grade of ESO. Educational microdata from the Community of Madrid allows us to analyze the evolution of the gender gap in mathematics scores in diagnostic assessments (Montalbán and Ruiz-Valenzuela, 2022). Following the same cohort of students, we observe that, while in 3rd grade of primary education (PE) the gap was 13 points, it increases to 20 points in 6th grade of PE and to 26 points in 4th grade of ESO, being statistically significant in all grades. It is expected that with the next diagnostic evaluations that the Ministry of Education has committed to in the coming years, a comparable gap can be calculated for the whole territory.

Evidence · **The origin of the gaps**

1. Gaps emerge and grow as people advance in their educational journey

The origin of gender gaps in mathematics achievement and the reasons behind them have been the subject of debate for more than half a century (Sweeney, 1984; Fennema & Sherman, 1978; Goldin, 1994). Most of the evidence on which we support the answers shown here, chosen strictly on the basis of quality and rigor, suggests that the mathematics gap does not exist before male and female students enter school, but becomes significant and increases throughout basic education.

(e.g., in the United States: Fryer and Levitt, 2010; in Italy: Contini et al., 2017; in the United Kingdom: Borra et al., 2023). Research points to two main theories in explaining these gaps, which tend to be presented as a dichotomy: biological and sociocultural differences. The former, which enjoy less scientific support, focus on divergences in brain composition, hormonal or spatial abilities, while the latter, which we will focus on throughout the report, attribute the gap to a variety of factors such as gender stereotypes and roles, teacher treatment and parental expectations, among others.

Gender differences in self-perceptions of brilliance in general and mathematical ability in particular appear in early childhood: by age six, girls already report lower self-concepts than boys, despite comparable performance on objective tests. Two studies in the last decade focus on recording the perceptions of 5- and 6-year-old boys and girls, offering initial insight into when they begin to develop gender-differentiated perceptions of math intelligence and ability. At age 5, girls and boys do not differentiate by gender their expectations of brilliance; however, by age 6, both boys and girls categorize boys as the "really smart" people, with girls moving away from games and activities they consider intended for this type of person (Bian et al., 2017). Likewise, at age 6 they state, both implicitly and explicitly, that mathematics is "a boy's thing," and at the same age they identify with mathematics to a greater extent than girls (Cvencek et al., 2011).

These gender stereotypes evolve in domains that fall under the STEM umbrella and grow over time: a series of experiments for male and female students aged 5 to 18 in the United Kingdom and the United States found an equal trend in the evolution of responses to questions about which gender tends to be good at STEM, which can be good at STEM, which should be good at STEM, and which should be good at STEM (McGuire et al., 2020). In early childhood, both boys and girls show a positive bias toward their own gender; in later years, only boys continue to show such a bias toward their gender-which opens a self-perception gap; in adolescence, responses again tend to become more equitable. In a complementary way an ambitious and recent study for the UK case relied on a survey following adolescents during their educational development to identify a clear relationship between puberty (publicly or socially evident markers of pubertal development) and mathematics achievement, strongly related to boys' and girls' self-perceived ability in mathematics, which "suggests that the mechanisms underlying the relationship between pubertal development and the mathematical gender gap are social rather than biological in origin" (Borra et al., 2023).

2. Gaps are smaller in more egalitarian cultural contexts

Gender roles play a fundamental role in mathematics performance: countries and families with more egalitarian gender norms have a smaller mathematics achievement gap. Exploratory country-by-country comparative analysis may suggest that there is a positive correlation between measures of gender equality and the mathematics gap (Guiso et al., 2008), or that the gap fades to zero for OECD countries with higher GDP per capita when other factors are taken into account (Anghel et al. 2020). But perhaps the most robust evidence of this importance can be found in studies that focus on data on second-generation migrant students. By analyzing how the gender norms in the country of origin affect the gender gap in mathematics achievement, it turns out that the gap disappears in students whose parents belong to more egalitarian cultures (Nollenberger et al., 2018). This effect is mediated especially by more positive attitudes about the role of women in the society of origin, being this modulator even more relevant when girls attend centers with a higher male concentration[7].

The context also operates at the household level, regardless of the broader cultural background: in an interesting analysis studying the correlation between household gender attitudes and mathematics performance, the authors claim that girls who grow up in families with a preference for boys and those whose mothers have less egalitarian attitudes towards gender roles perform worse in mathematics (Dossi et al., 2020). Interestingly, in a later paper, the same authors find that gender attitudes explain girls' lower mathematics performance only in relatively affluent white families, while they are apparently not as important for the performance of girls from families with other socioeconomic profiles (Dossi et al, 2021).

3. The immediate learning context also modulates the learning gap

Teachers and the classroom environment influence children's academic outcomes. Aspects such as classroom composition and teacher attitudes and behavior affect both academic achievement and students' educational and career choices. In Greece, where students are randomly assigned to classrooms at the beginning of high school, data suggest that a higher proportion of female classmates improves scores in STEM subjects especially for girls, suggesting that the gender composition of classrooms may have long-lasting effects on their educational and career outcomes (Goulas et al. 2023).

Teacher gender significantly influences students' performance and motivation in science and mathematics at all educational levels (Bettinger et al., 2015; Carrel et al., 2010). Moreover, the way teachers interact with their students and their perceptions of their students' abilities exert a notable impact on their academic performance and decisions about their future educational trajectories (Sansone, 2017; Lavy and Sand, 2018). In addition, there are considerable biases in teachers, as evidenced in a qualitative study (Hand et al., 2017), where it is observed that they tend to associate male characteristics with the sciences and female characteristics with areas such as the humanities, also believing that boys perform better in STEM subjects.

4. Difference in the top due to different inclination to compete

The existence of grade differences especially among high achievers could be explained, at least in part, by the well-documented gender gap in willingness to compete. In this sense, the response to competitive environments does indeed seem to differ between males and females, and this gender gap in competitive performance is not reflected in non-competitive performance (Niederle and Vesterlund, 2010). These differences could imply, according to this study, that certain math test scores could be exaggerating the advantage of males over females, especially in the higher-scoring ones. In the same vein, a natural experiment exploiting variation in test stringency observed that female high school students outperform male students on all tests, but to a greater extent when the level of stringency is lower (Azmat et al, 2016).

[7] Complementarily, Gevrek et al. (2020), also using PISA data, find that greater gender equity in access to tertiary education and a smaller gender wage gap are associated with a smaller unexplained share of the gender gap in mathematics.

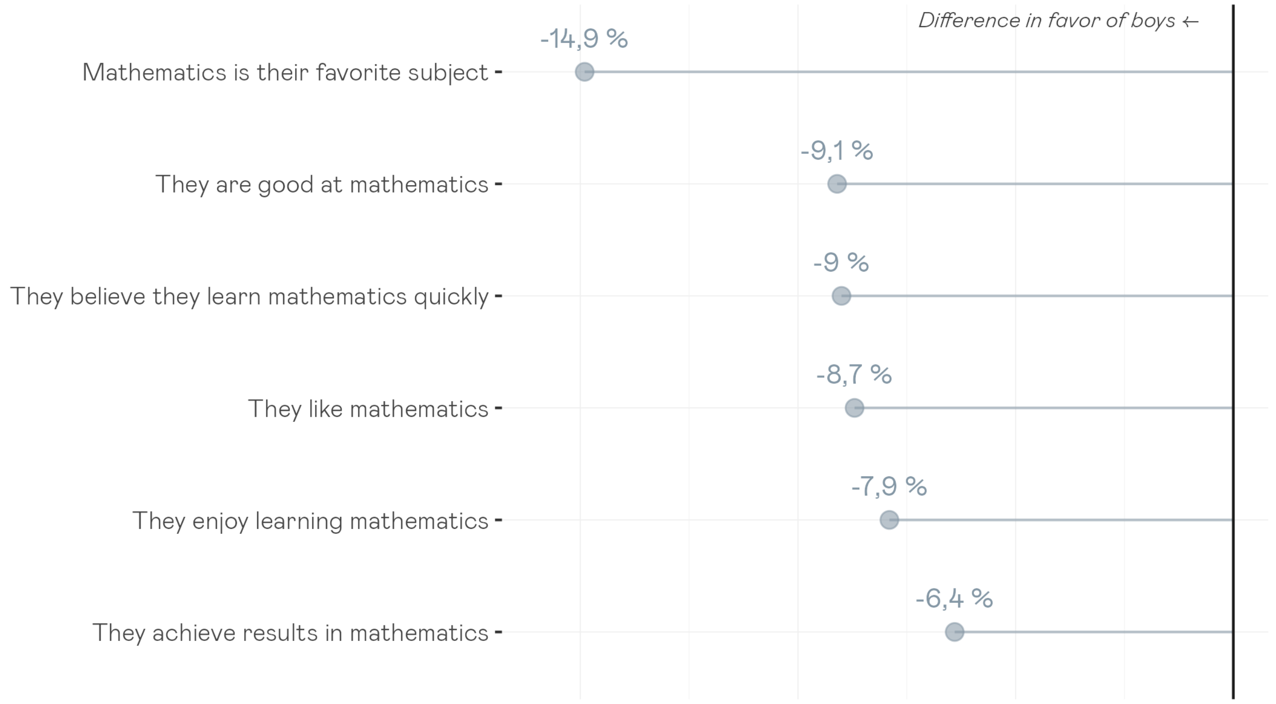
5. The concreteness of the gap in affect, self-perception and anxiety towards mathematics.

Finally, the evidence shows that girls have higher levels of math anxiety and less enjoyment of math and science —potentially related to gender roles and self-perception—, which directly impacts their performance. An exploratory analysis of gender differences in the emotional experience of seven- to fifteen-year-old students in mathematics found in 2015 that girls have higher math test anxiety and that, moreover, this anxiety is negatively related to performance only in the case of girls (Erturan and Jansen, 2015). This mathematics anxiety appears to be negatively related to girls' mathematics performance as early as age seven (Van Mier et al, 2019). And when controlling for test anxiety in general, the negative correlation between math anxiety and performance remains significant only in girls (Devine et al., 2012). This suggests that math anxiety could be a specific limiting factor for girls' math performance, whereas for boys this relationship is less clear. The evidence also points to an intergenerational transmission mechanism of mathematics performance and anxiety. When parents show greater concern about mathematics, their children would learn less and have more anxiety about the subject, but only when parents provide frequent help with homework (Beilock and Maloney, 2015).

Mathematics affection, self-perception, anxiety in math and outcomes in Spain.

In Spain, there are already gender gaps in 4th grade of elementary school in the emotional experience in mathematics, with girls having a lower self-perception, greater mathematical anxiety and lower levels of enjoyment. The surveys associated with the TIMSS test (2019) provide us with information to estimate the gender gap in variables related to self-perception and affection for mathematics in 4th grade of Primary Education. Figures 4 and 5 show the estimates of the gender gap (girls versus boys) using a probabilistic model (probit hereafter).

Figure 4. **Difference in the estimated probability of girls vs. boys having positive feelings in mathematics**

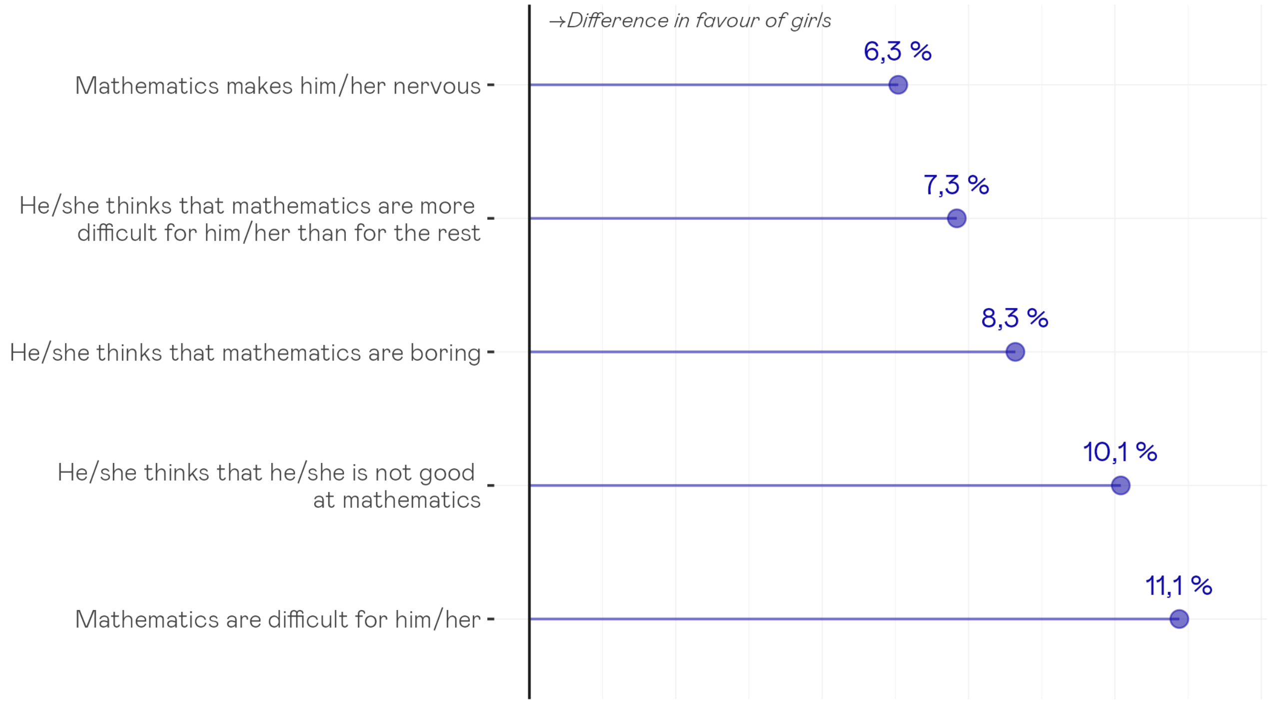


Source: TIMSS (2019) | EsadeEcPol

*All estimates shown here are from probabilistic models and are statistically significant at <0.01.

Girls are less likely than boys to have a positive feeling towards mathematics, with a 9% lower probability that they consider themselves good at it and quick learners. They also show less affection, with a 15% lower probability of considering mathematics their favorite subject and an 8.7% and 7.9% lower probability of liking or enjoying learning, respectively. When the statements are negative (negative self-perception, difficulty and math anxiety), the ratios are inverted: the probability of considering that mathematics is difficult for him/her is 11% higher in the case of girls; 8% more think that mathematics are boring and the probability of getting nervous is also 6.3% higher in the case of girls.

Figure 5. **Difference in the estimated probability of girls vs. boys having negative feelings in mathematics**



Source: TIMSS (2019) | EsadeEcPol

*All estimates shown here are from probabilistic models and are statistically significant at <0.01.

Despite the fact that at 15 years of age girls report making a greater effort than boys to understand mathematics, the gender gap in self-perception and affection for mathematics persists[8]. Estimating the gender gap again using probit models (Figure 6), we observe, firstly, that it continues to exist when analyzing the choice of favorite subject: the largest gap is in mathematics, with the probability of a girl considering it as her favorite subject being 10.3% lower. Regarding self-perception, the probability that a girl considers mathematics to be easy for her is 11% lower, with the opposite occurring in language. However, the probability that a girl wants to "do well in mathematics" is 5% higher for girls. Figure 7 presents the estimated gender gap in variables related to attention, participation, dedication and resilience. We see that the biggest differences are in the time dedicated to understanding the subject and the effort dedicated to performing the tasks, and there is also a significant gap in favor of girls in attention. However, girls drop out more when they do not understand, lose interest and present a lower level of active participation in the classes.

[8] Cabe mencionar, de nuevo, que los resultados de TIMSS y PISA no son directamente comparables (años y metodologías diferentes).

Figure 6. **Difference in the estimated probability of girls vs. boys agreeing or strongly agreeing with ____________** · 2022

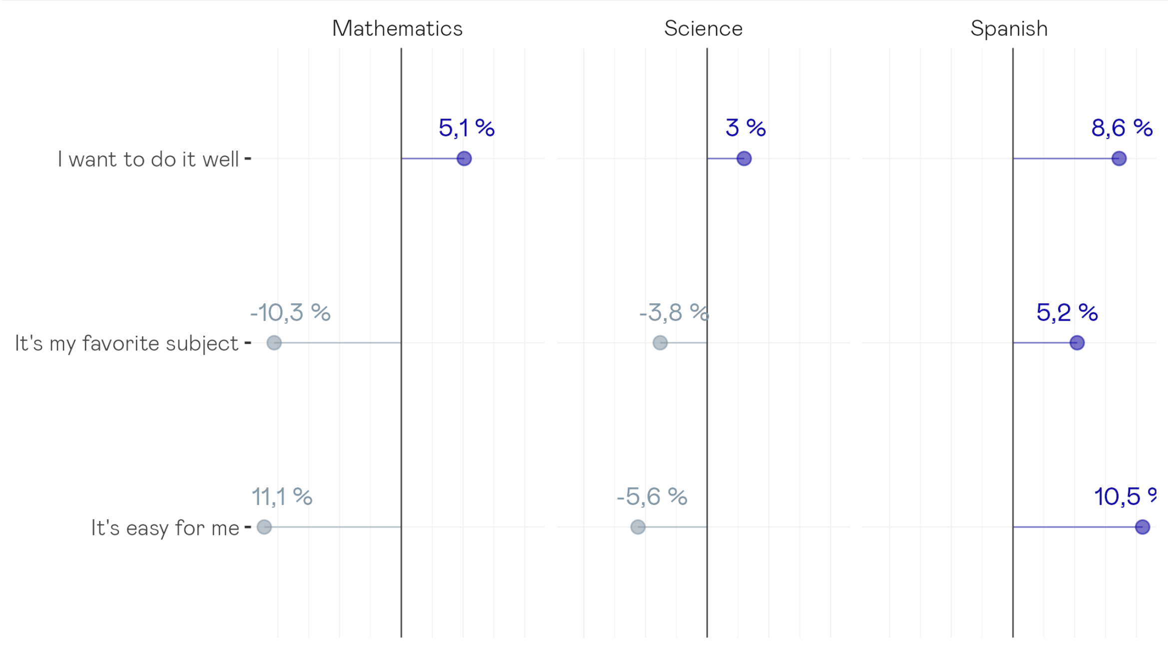
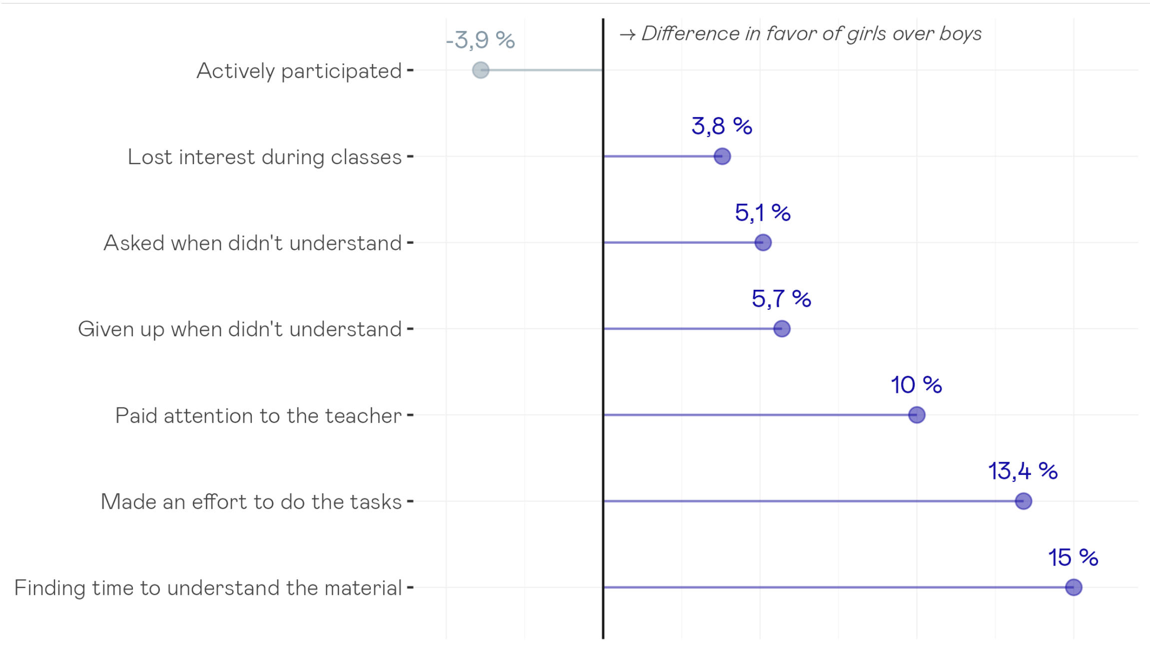


Figure 7. **Difference in the estimated probability of girls vs. boys that they had __________ in more than half of the math classes**

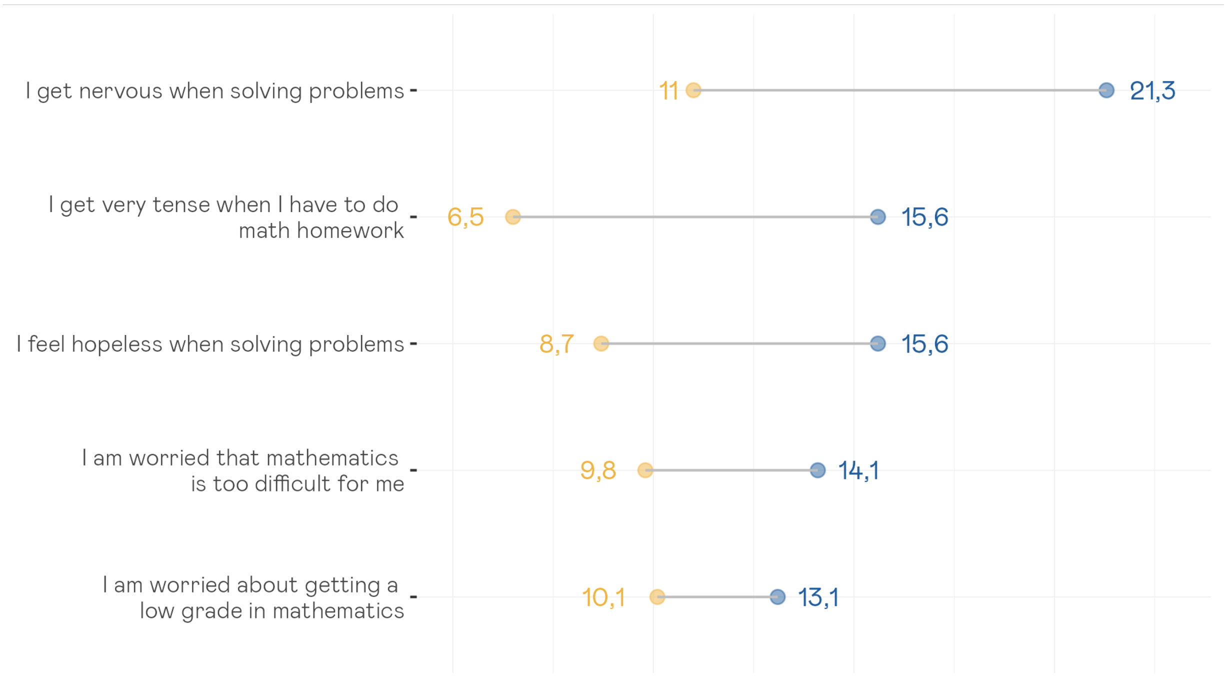


Source: PISA (2022) | EsadeEcPol

*Todas las estimaciones aquí mostradas proceden de modelos probabilísticos y son estadísticamente significativos a <0.01.

The most relevant gender gap is in concern about difficulty and grades in mathematics, as well as in nervousness when solving problems, being in both cases greater for girls. Moreover, while the gap in scores has narrowed in the last decade, the gap in math anxiety has increased substantially. Using the same method, we estimate the gender gap in indicators related to what is known as "math anxiety" (Figure 8). The estimated probability of girls agreeing or strongly agreeing with the statement "I worry about getting a low grade" is 13% higher and 14.1% higher for worry about difficulty. Regarding nervousness about doing homework or solving math problems, the estimated probability of girls being more likely to agree or strongly agree is 15.6% for the former and 21.3% for the latter, with the gap having increased by around 10 percentage points in both indicators over the last decade.

Figure 8. **Increase in the estimated probability difference in girls vs. boys in agreeing with __________** · between 2012 and 2022



Source: PISA (2012, 2022) | EsadeEcPol

*All estimates shown here are from probabilistic models and are statistically significant at <0.01.

Positive self-perceptions of mathematics ability, as well as mathematics affections, have a positive relationship with scores. However, math anxiety reduces the average score, although this relationship has decreased substantially in the last decade. In an exploratory analysis using linear regression models of the relationship between self-perception, affect, and mathematics anxiety at 15 years and mathematics scores, we find that the relationship is positive and statistically significant and, moreover, of great magnitude in all variables. However, gender differences in these relationships are minor and, in some cases, irrelevant. As expected, having a better self-perception in mathematics is associated with between +25.4 points for boys and +26.7 for girls in PISA'22, being similar for mathematics affect: +24.3 and +23.3, respectively. On the contrary, feeling anxious about mathematics is associated with a reduction in the score of -20.8 points for boys and -18.6 for girls. In 2012 it was higher: -28.8 and -25.3 points respectively.

Career expectations of students in Spain: female disaffection with STEM careers

Evidence · **Gaps in self-perception and results become expectations**

Gender roles, self-perception, and thus the gender gap in mathematics, have an impact on girls' and adolescents' expectations of their future careers. Research has shown that career aspirations in childhood are linked to the actual careers that adults pursue later in life, and that gender plays a critical role in these expectations: girls are often more supportive of community values and less supportive of individual values, compared to boys, and these differences partly explain girls' relatively higher preference toward family over career (Block et al., 2018). Along the same lines, among the reasons argued by high school students for choosing STEM careers, helping people and society is more important for girls, while earning money is more important for boys (Merayo and Ayuso, 2022). Moreover, children's aspirations seem to be shaped by gender-specific ideas about certain jobs: according to the results of a survey (conducted and studied by Chambers et al., 2018), more than four times as many boys as girls want to be engineers, with almost twice as many boys wanting to be scientists as girls. According to the authors, conceptions of traditional femininity, specifically ideas around "nurturing" roles, could explain part of these differences. Along these lines, a recent study following the same individuals over time through surveys shows that these traditional gender role beliefs in adolescence predict a lower likelihood that girls will pursue STEM careers related to physical science, mathematics, engineering, and technology in adulthood (Dicke et al, 2019). And finally, children's expectations about their future career and family seem to be not only associated not only with their own gender schemas, but work hours and the division of tasks in the family home play a key role in determining how they conceive of their future work and role in the family (Endendijk and Portengen, 2022).

Being in the top 20% with the best math scores increases the probability of being projected into a STEM career at age 30 by 21%, and this effect is greater for boys. Self-concept and affect also have a relationship with STEM career projection. In PISA, at age 15, students are asked about the profession they imagine themselves in at age 30. With this question, we created a category: "STEM expectation", which groups together occupations related to STEM fields with the highest precision available[9], excluding medical-related occupations. First, we estimate, again using a probit model, how performance (dividing the total grades into five equal groups, each corresponding to 20% of the total student body, from the top 20% to the 20% with the lowest relative grades), self-concept and mathematics affectation are related to these expectations. As might be expected, the students in the top 20% with the best grades in mathematics are 21% more likely than the students with the worst grades to project themselves into a STEM profession. However,

[9] From the open-ended responses, they perform a four-digit coding of occupations following the ISCO-08 standard. The fields that the OECD considers STEM can be found in OECD (2019), page 214, being primarily categories 21, 25, 31 and 35, with certain exceptions.

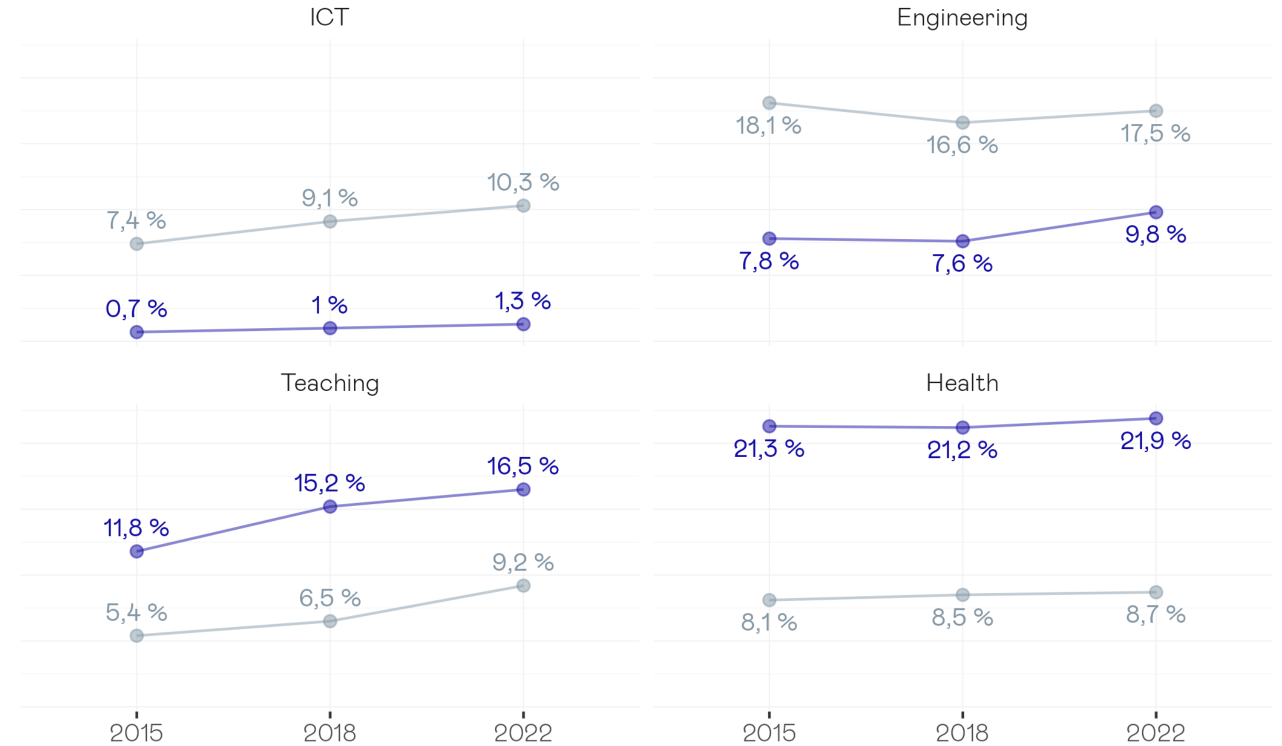
when it comes to students in the median performance (in the middle quintile), these differences are close to zero. Moreover, this relationship between performance and expectations is stronger for boys (24%) than for girls (17.1%). Affection for mathematics and self-concept have a smaller effect on the probability of projecting oneself into a STEM occupation (6.9%, 6.3%, respectively), with gender differences also much smaller.

The probability of aspiring at age 15 to have a STEM profession at age 30 is 12.7% lower for girls than for boys, and this gap is practically unchanged when we take into account the level of student performance. Boys continue to prefer occupations in the fields of engineering, science, and ICT, while girls' aspirations are dominated by healthcare and teaching. Focusing on the gender gap in job expectations in STEM occupations, we estimate that the probability of a girl projecting herself into a STEM occupation is 12.7% lower than for boys. Interestingly, when we take into account mathematics performance, the gap drops to only 11.5%. However, while this gender gap for the lowest performance is only 6.2%, it doubles for the top achievers to 13.7%.

Breaking down the analysis and observing its evolution in descriptive terms, Figure 9 shows the percentage of boys and girls who, at age fifteen, see themselves working in: (a) engineering and other sciences such as physics, chemistry, mathematics or biology; (b) information technology professionals; (c) health professionals; (d) teaching, as well as the evolution of expectations over the last seven years.

In engineering and other sciences, the gap has narrowed slightly, with the current difference being 7.7 percentage points, while in 2015 it was 10.3; even so, while 17.5% of boys aspire to pursue careers in engineering and other sciences, only 9.8% of girls have such an aspiration. In occupations related to ICT the gap is the most pronounced: while 10.26% of boys aspire to these professions —considered to be the "professions of the future"— only 1.25% of girls do so, and this gap is the only one that has grown in recent years. However, aspirations in health and teaching professions continue to be dominated by girls, with the gap narrowing in the case of teaching.

Figure 9. **Evolution of the percentage of girls and boys who want to dedicate their lives to**



Source: PISA (2022) | EsadeEcPol

Gaps beyond basic education

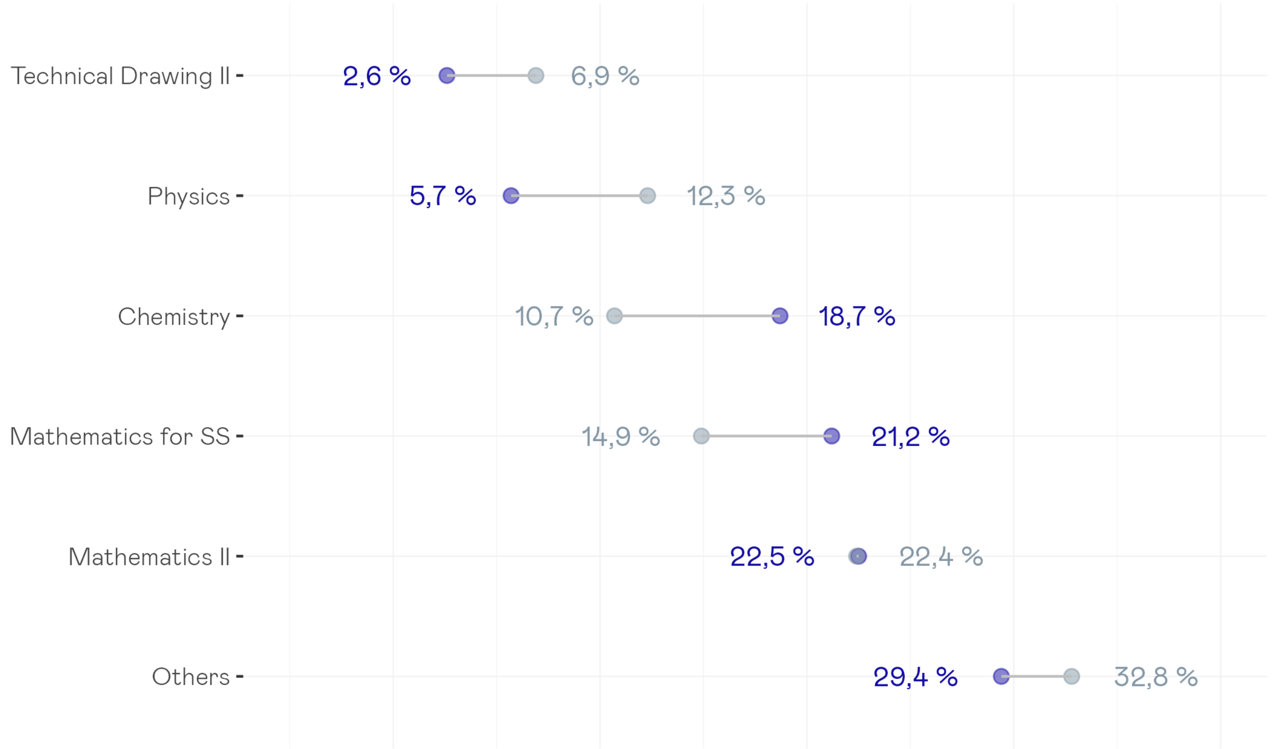
High School and university entrance exams

To continue with our analysis we capitalize on data from the Integrated University Information System (SIIU) and those compiled by the STEAM Alliance Ministry of Education and Vocational Training to offer a complete x-ray of how expectations land in choices from the moment they become available to girls and boys.

Once the compulsory stage of education has been passed, the first gap in the choice of modalities that will ultimately determine whether a person embarks on a STEM career or not is observed in high school: despite having a higher rate of promotion with all subjects passed at the end of the stage, regardless of the modality, girls opt more for the Arts and Humanities modalities. In 2021 (the latest available data), the gender distribution by high school modalities were as follows: in the Arts pathway, 76% of the students enrolled were girls; in Humanities, 64%; in Social Sciences, 54%; and in Sciences, 48% (Ministry of Education, Vocational Education, and Sports, 2021). It should be noted that the Science modality includes two sub-modalities which, since 2008, have not been disaggregated: technological and bio-health. In the last year for which data are available, the percentage of girls in the former was 21.5%, while in the bio-sanitary branch it was 51.2%. Given the evolution for the rest of the modalities, we do not assume major changes in the distribution of students enrolled in these modalities. Thus, the first gap in the choice of modalities is observed: girls self-select themselves when it comes to choosing the technology pathway. As a measure of performance by mode of high school, only the promotion rate with all subjects passed is available. Girls have substantially higher promotion rates in all modalities, including Science: 63% in Arts (compared to 51% of boys); 67% in Humanities and Social Sciences (compared to 54%) and 79% in Science (compared to 73.5%).

In the university entrance exams, girls choose less the subjects of Physics and Technical Drawing. Even so, their admission score in STEM subjects is slightly higher than that of their peers. Even so, their admission score in STEM subjects is slightly higher than that of their peers. Despite the difficulty in drawing conclusions about selection of modalities in high School due to the scarcity of data, the data from the University Entrance Exams provided by the Integrated University Information System (Ministry of Universities) allow us to delve deeper into the choice of pathways. Figure 10 shows that the percentage of girls and boys who take Mathematics II in EBAU (compulsory for the branch of Science, regardless of the choice of biosanitary or technological) is practically the same and that more girls than boys take Chemistry (18.7% vs. 10.7%). However, only 2.6% of girls take Technical Drawing (compared to 6.9% of boys) and 5.7% of girls take Physics (compared to 12.3% of boys). This contrasts with the results of the average admission score, whose gender differences are low and in favor of girls. In 2022/2023, girls obtained in Engineering and Architecture an average of 10.35 (compared to 9.89 for boys); in Sciences, the gap is only 0.05 in favor of girls (11.26) and in Health Sciences, the gap is slightly larger (average of 11.54 for girls and 11.24 for boys), as well as in Social and Legal Sciences and Arts and Humanities.

Figure 10. **Percentage of girls and boys taking the university entrance exam by subject** · 2020



Source: STEAM Alliance, Ministry of Education and Vocational Training (2021) | EsadeEcPol

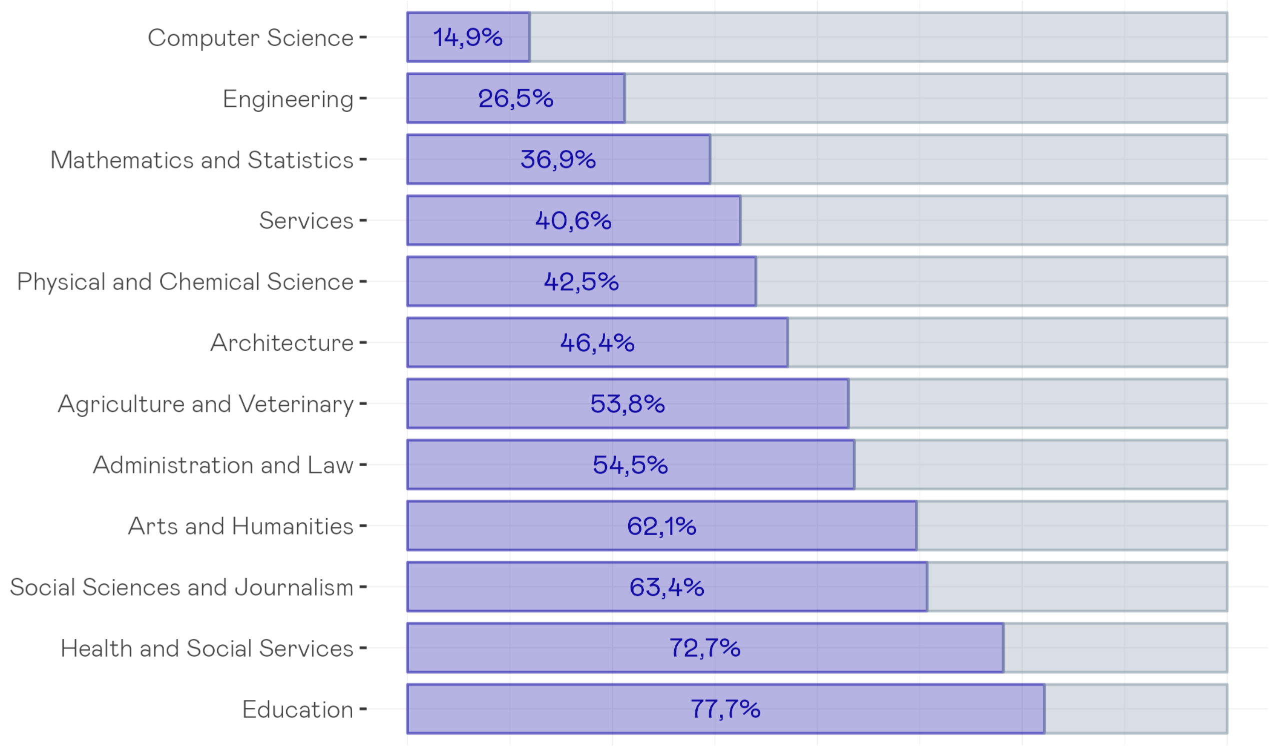
Evidence · **The different inclination to compete and its effects**

The lower willingness of girls to compete may explain, at least in part, the gender gap in early choice of science modalities, indicating not only that boys are more likely to compete but also that this difference may explain much of the gender gap in choice of major in high school (Buser et al, 2017). The gender gap in the choice of STEM pathways in High school — which is, practically, the first choice of itineraries they make before choosing a university degree or Vocational Training— is not a reality exclusive to Spain: it is also observed in secondary school in the case of the Netherlands (Buser et al., 2014), in High school in the case of Switzerland (Buser et al., 2017). Both studies analyze whether the gender gap in mathematics specialization can be predicted by an experimental measure of willingness to compete. They find that students with a higher propensity to compete, regardless of grades, have a higher probability of choosing a mathematics major, with boys being more likely to compete. These differences foretell notable gender differences in the choice of college majors.

Gender gap in the university

In light of the data already seen for the university entrance exam, it will come as no surprise to learn that **boys predominate in STEM degrees, with the gap being especially pronounced for computer science and engineering degrees; however, girls opt for degrees in education, health and social services.** Figure 10 shows the gender gap for enrollment in university degrees by field of study (Ministry of Universities). The largest gender gap in STEM fields is in computer science, where only 14.9% of enrolled students are girls, followed by engineering, with 26.5% of girls enrolled. The gap is equally high for mathematics and statistics and physical and chemical sciences (37% and 42.5% of girls, respectively). However, if all sciences are considered, the gap disappears due to the effect of life sciences, with a majority of girls (61%). The opposite occurs in health and social services degrees, which continue to be branches of knowledge dominated by female students: nursing stands out with 82% of girls enrolled, and social work and counseling with 84%. In the field of education, the training of early childhood education teachers stands out, with 91% of girls enrolled.

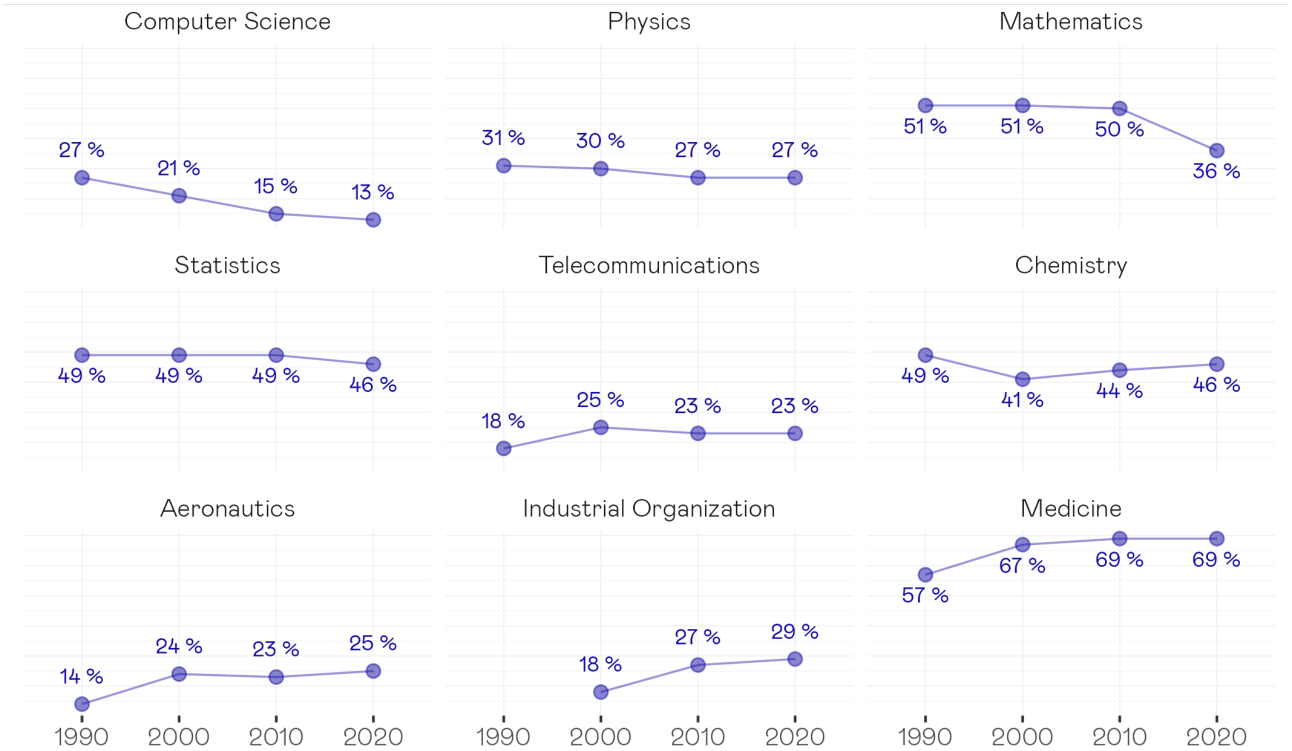
Figure 11. **Women and men enrolled in university degrees** · '21 -'22



Source: Integrated University Information System (2022) | EsadeEcPol

More striking is the drop in enrollment in specific degrees. Figure 11 shows the evolution of the percentage of girls enrolled in a selection of university degrees and STEM fields since the 1990s. The percentage of girls enrolled has fallen substantially in Computer Science, from 27% in 1990 to 13% in 2020. A similar drop occurs in Mathematics, where, from 2010 to 2020, the percentage of women goes from representing half of the enrolled students to 36%. In Statistics, the percentage decreases slightly (3 percentage points) and in Telecommunications Engineering, although it increases from 18% to 25% in the first decade, it has remained practically constant over the last 20 years. The fields with the greatest increase in the percentage of women enrolled are Aeronautical Engineering and Industrial Organization Engineering, with an increase of 10 points. However, in Aeronautics the increase takes place in the first decade and, again, stagnates in the year 2000, representing only 25% of those enrolled.

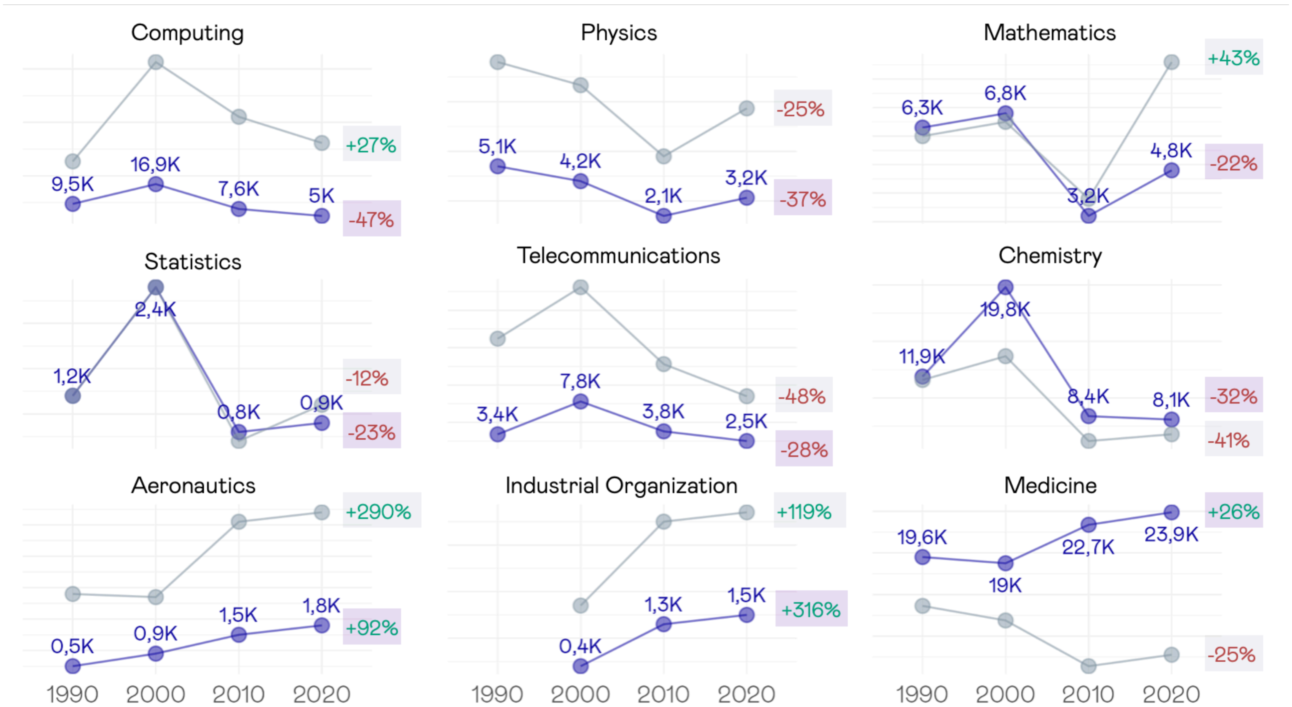
Figure 12. **Evolution of the percentage of women enrolled in university degrees by field of study**



Source: STEAM Alliance, Ministry of Education and Vocational Training (2021) | EsadeEcPol

Figure 12 complements the previous one, showing the total number of male and female students enrolled by field. This allows us to understand whether the evolution of the distribution of the student body is due to differential variations in the number of students enrolled. In Computer Science and Physics, the percentage of girls enrolled out of the total falls because the absolute drop of girls in these fields is greater than that of boys. In Mathematics, however, the number of students enrolled has increased (42%) and the number of female students has fallen over the last decade. In Aeronautics and Industrial Organization, both boys and girls enrolled are increasing, but the percentage of girls is higher in the latter. Finally, in Telecommunications, the number of enrolments decreases for both genders, but more so for boys.

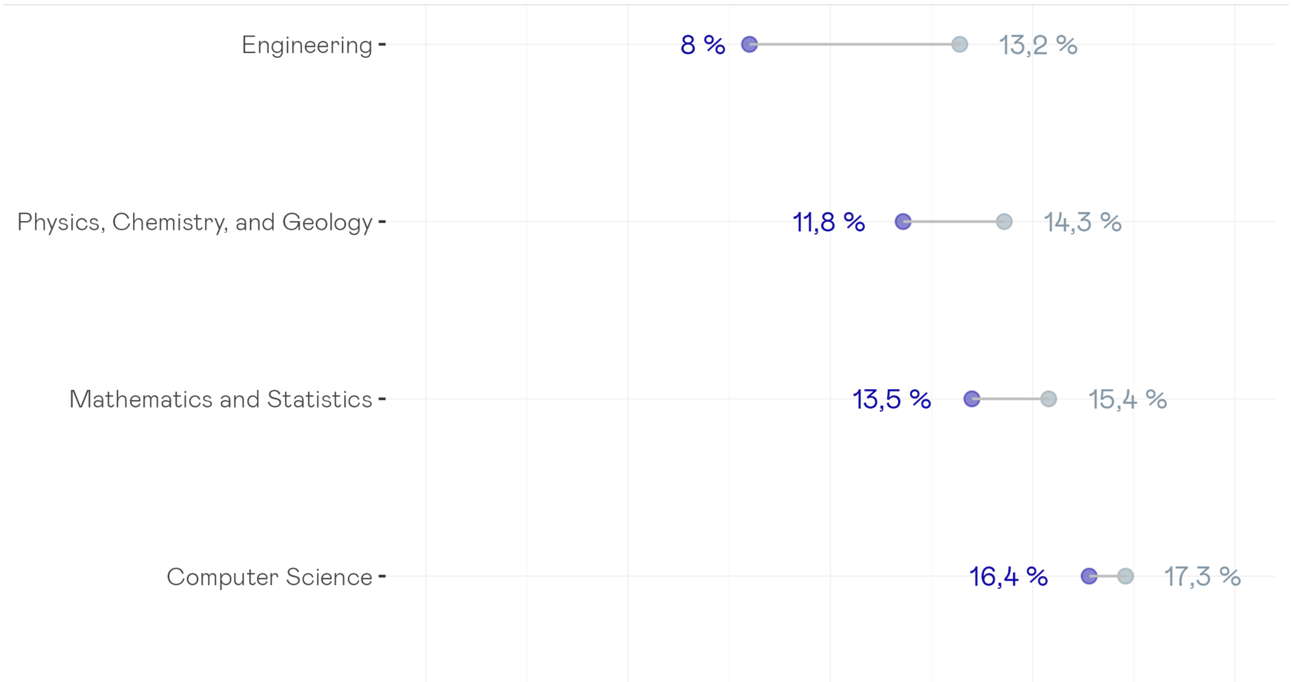
Figure 13. **Evolution of the number of women and men enrolled in university degrees by field of study**



Source: STEAM Alliance, Ministry of Education and Vocational Training (2021) | EsadeEcPol

Nevertheless, it turns out that girls' performance in STEM degrees, as measured by first-year dropouts, is better than that of boys. Even so, given the low enrollment, the gender gap in STEM graduation is very pronounced: only 30.7% of STEM graduates are women. As is the case throughout the entire educational stage, despite a lower presence of women, the educational results of women are superior. Figure 13 represents the dropout rate in STEM degrees during the first year. We see that in all degrees the dropout rate is high for both men and women, but especially for men who, in engineering, drop out on average 5 percentage points more. Even so, the gender gap in STEM graduation remains very high: less than 31% of STEM graduates are women. Moreover, surprisingly, the percentage of both male and female STEM graduates has declined over the last five years (with a greater percentage drop for the latter): in the 2015/2016 academic year, 12.1% of female university graduates did so in STEM fields (14.4 thousand) compared to 37.2% of men (31.4 thousand); however, in the academic year 2021/2022, only 9.1% of women (10.8 thousand) and 31.2% of men (24.5 thousand) did so.

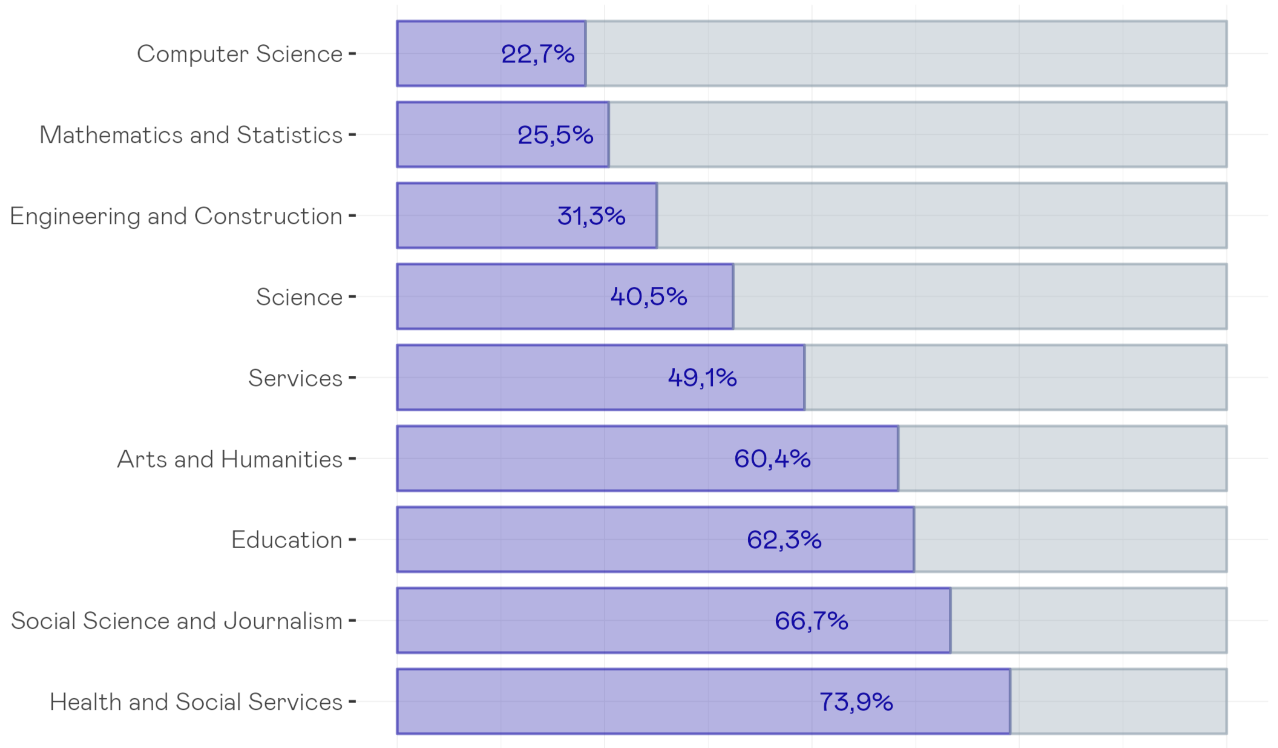
Figure 14. **Women** and **men** **first-year dropouts** · '21-'22



Source: EDUCABase (2020) | EsadeEcPol

In master's degrees, the gender gap in STEM fields is maintained: only 11% of female master's degree graduates are STEM graduates, compared to 26% of men. Figure 14 represents the distribution of people enrolled in master's degrees in Spain in the 21/22 academic year, according to gender. Again, the largest gap in favor of men is in Computer Science (slightly lower than the undergraduate gap), followed by Mathematics and Statistics (with a higher gap than the undergraduate gap) and Engineering. In Education, the enrollment gap decreases —although women continue to predominate, representing 67% of the total— and increases slightly in Health and Social Services, where women represent 74% (Integrated University Information System, 2022).

Figure 15. **Women and men first-year dropouts** · '21-'22



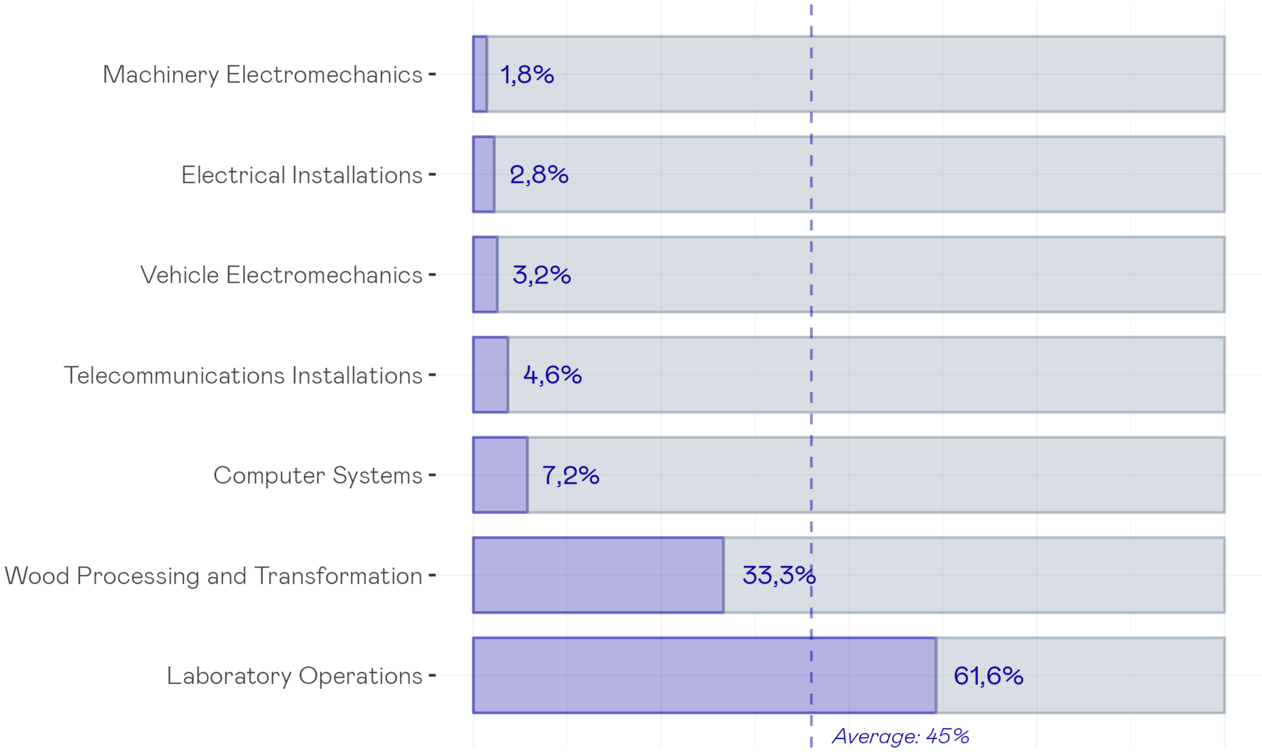
Source: Integrated University Information System (2022) | EsadeEcPol

Gender gap in Vocational Training

Vocational Education and Training (VET) in Spain has been, for years, neglected in the Spanish educational landscape. However, especially since the financial crisis, which highlighted the relevance of VET in the country with the highest early school dropout rate and a youth unemployment rate more than double the European average, VET has gained importance: currently, 33.7% of people enrolled in post-compulsory education are enrolled in VET. It is therefore equally relevant to understand the gender gaps in STEM VET degrees.

Of all male graduates in VET, 52% are in STEM fields, compared to only 7% of women. Thus, out of the total number of people graduating in VET, only 3.4% are women graduates in STEM, thus giving the greatest gender differences in education (Ministerio de Educación, FP y Deportes, 2022). Figure 15 shows the percentage of men and women enrolled in a selection of STEM fields in the 21/22 academic year. We can see that, in most cases, female representation does not reach 5% and it is only in the Intermediate Vocational Education in Laboratory Operations where more than half of the students are women.

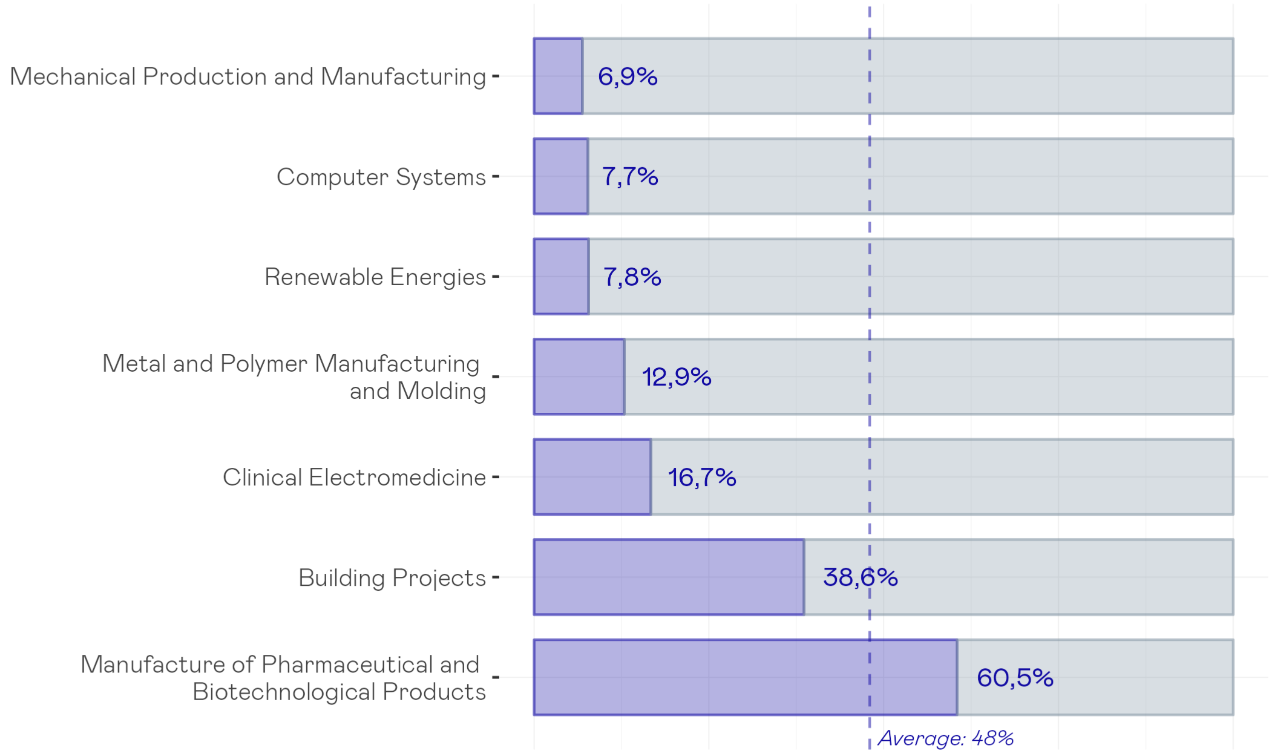
Figure 16. **Women** and men **enrolled in intermediate grade of Vocational Education** · '21-'22



Source: Statistics on Non-University Education of the MEFP | EsadeEcPol

In the advanced degree in Vocational Training we find many more degrees that can be considered part of the STEM field, as well as a greater representation of women in some of them. Figure 16 presents a selection of these degrees, choosing those with the highest enrollment volume. Again, in most of them the female participation does not exceed 10%, especially in those related to transportation, vehicles, installations, and maintenance. Although, those related to building and civil engineering have a higher percentage of women (close to 40%), and those related to 3D animation, games and interactive environments have 26.4%.

Figure 17. Women and men enrolled in advanced degree in Vocational Training · '21-'22



Source: Statistics on Non-University Education of the MEFP (2022 | EsadeEcPol

Evidence · Mechanisms that trigger differences in career choice

Research has tried to analyze the roots behind these gender differences in career choice, pointing out that they may be influenced by a combination of perceptions of competence, academic feedback, and other sociocultural factors. Aspects such as self-confidence and role representation play a crucial role in making these educational decisions. Thus, a study using granular data with gender differences in university applications in Chile showed that men have, regardless of their qualifications, a greater propensity to apply to selective programs, while women tend to be more cautious, suggesting differences in self-confidence and in the perception of one's own abilities between genders (Bordón et al., 2020). Along the same lines, detailed data from a U.S. university suggest that women are more likely to switch majors particularly in male-dominated fields and in STEM, pointing to a greater susceptibility to signals of not belonging (Kugler et al., 2021). However, based on the results of an experiment conducted by Owen (2023), providing relative performance information, while reducing gender differences in the (biased) beliefs of boys and girls, does not greatly influence subject and career choice. On the contrary, it has been shown that the representation and exposure to role models can counteract these preconceived biases. For example, Porter and Serra (2020) find that exposure to successful and charismatic women in fields such as economics significantly increases the likelihood that female students will choose to major in these areas.

Careers: finishing point

Although it is likely, it is far from automatic that a person trained in STEM will end up in a job associated with this field. Even less so in a labor market such as the Spanish one, in which the mismatches between labor supply and demand by skill level are considerable: Spain is among the OECD countries with the lowest degree of alignment between the skills offered and demanded (OECD, 2019). This concern is accentuated in the case of women, whose labor careers are interrupted with greater frequency and depth, especially for those who become mothers (Hupkau and Ruiz-Valenzuela, 2020; Quinto et al, 2021).

This is why no analysis of the presence of women in STEM can be fully complete without answering what their actual presence in occupations of this type is, how it compares with that of men, how it is distributed among sectors or qualification profiles, to what extent it corresponds to what has been studied, and also whether the fact of being employed in these segments has any discernible relationship with the gender gaps that, as a general rule, are observed in the Spanish labor market (Hupkau and Ruiz-Valenzuela, 2020).

To proceed**, we need first of all a categorization of STEM occupations**. In the statistical sources of the Spanish labor market, two standardized classifications are mainly used: the 2011 National Classification of Occupations (CNO11) and the 2008 International Standard International Classification of Occupations (ISCO), which we have already discussed in the section on labor market expectations of boys and girls. After an exhaustive methodological review (detailed in the appendix), **we propose a novel indicator**, constructed from a selection of both a series of occupations at a sufficient level of disaggregation to provide sufficient analytical detail and good capacity to identify occupations with a high STEM content, but not so high as to prevent the use of these sources due to loss of sufficient sample or excessive de-anonymization[10], limited in any case by the maximum level of disaggregation available in a Spanish public data source that contains, in addition to the occupation variable, the other variables that allow us to complete the analysis.

The source that allows us to answer the above questions is the Living Conditions Survey (LCS), which includes in its public microdata a sufficient breakdown of the type of occupation for each person, as well as data on sector of activity, age, type of working day, or level of income and salary received.

How many women are there in STEM occupations?

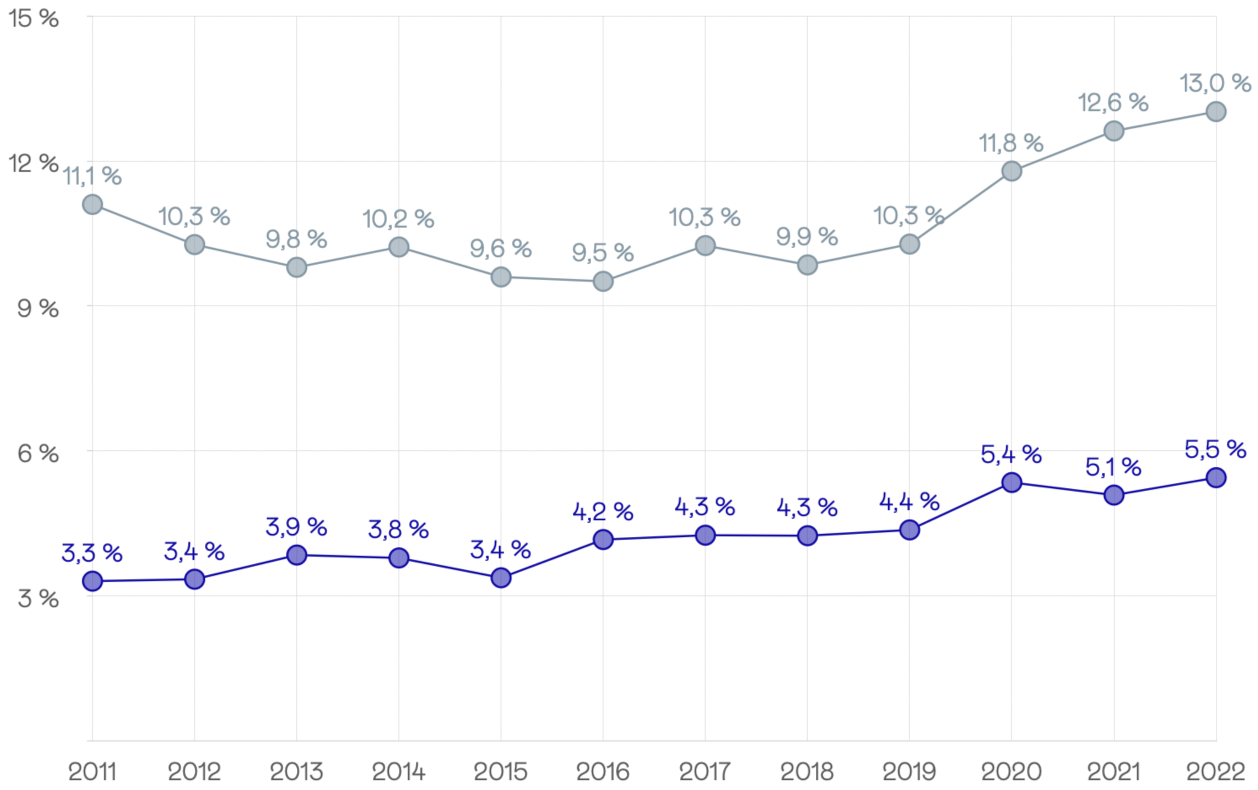
The percentage of women who have a STEM occupation out of the total number of women employed in Spain at the end of 2022 is 5.5%. For men, that figure reaches 13%, so the ratio is x2.4 in favor of men. It is true that the rate for women has increased steadily and substantially since 2011, but the starting point is so low (3.3%) that even if we have a 66% increase, the result is still much lower than their male counterparts.

[10] The latter prevents us from going down to a greater level of disaggregation as the PISA data do for job expectations, which means that the following classification cannot completely coincide with the one offered in that section.

Classification of STEM occupations

	International Universal Classification of Occupations (CIUO) 2008	**2011 National Classification of Occupations** (CNO11)
STEM Professional	21 Science and engineering professionals	24 Professionals in the physical, chemical, mathematical and engineering sciences: Physicists, chemists, mathematicians and related professionals; Professionals in the natural sciences (biologists, agronomists, foresters, agricultural technicians, etc.); Engineers; Architects, urban planners and geographic engineers; Technical engineers; Technical architects, topographers and designers.
	25 Information and communications technology (ICT) professionals	27 Information technology professionals: software and multimedia analysts and designers; database and networking specialists
STEM Technician	31 Mid-grade science and engineering professionals	31 Science and engineering technicians: draughtsmen and technical draftsmen; physical, chemical, environmental and engineering science technicians; process control technicians (technicians in energy production facilities, waste and water treatment facilities, oil and natural gas refinery technicians, etc.); natural science technicians and related auxiliary professionals; maritime and aeronautical navigation professionals; physical, chemical and engineering science quality control technicians.
		32 Mining, manufacturing and construction engineering supervisors
	35 Information and Communications Technology Technicians	38 Information and communications technology (ICT) technicians: Information technology operations and user support technicians; Computer programmers; Audiovisual recording, broadcasting and telecommunications technicians

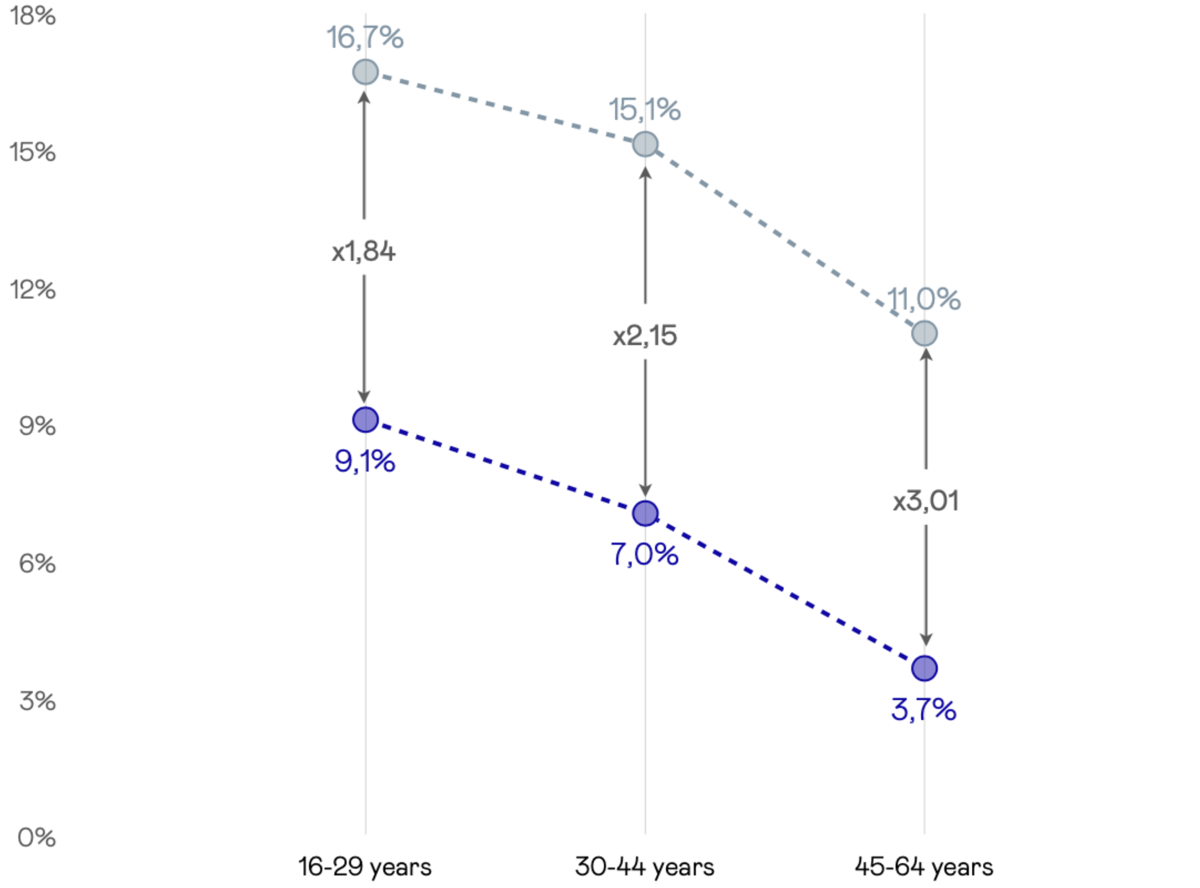
Figure 18. **Evolution of the percentage of women and men in STEM occupations** · between 2011 and 2022



Source: Living Conditions Survey (2022) | EsadeEcPol

Dividing the data by age groups, we observe that this gap exists for all age groups, although it is smaller for the younger generations: **among those under 30 years of age, women in STEM occupations account for 9%, but it drops to 7% among those between 30 and 44 years of age.** Even so, participation in these groups is above average, marked by older ages.

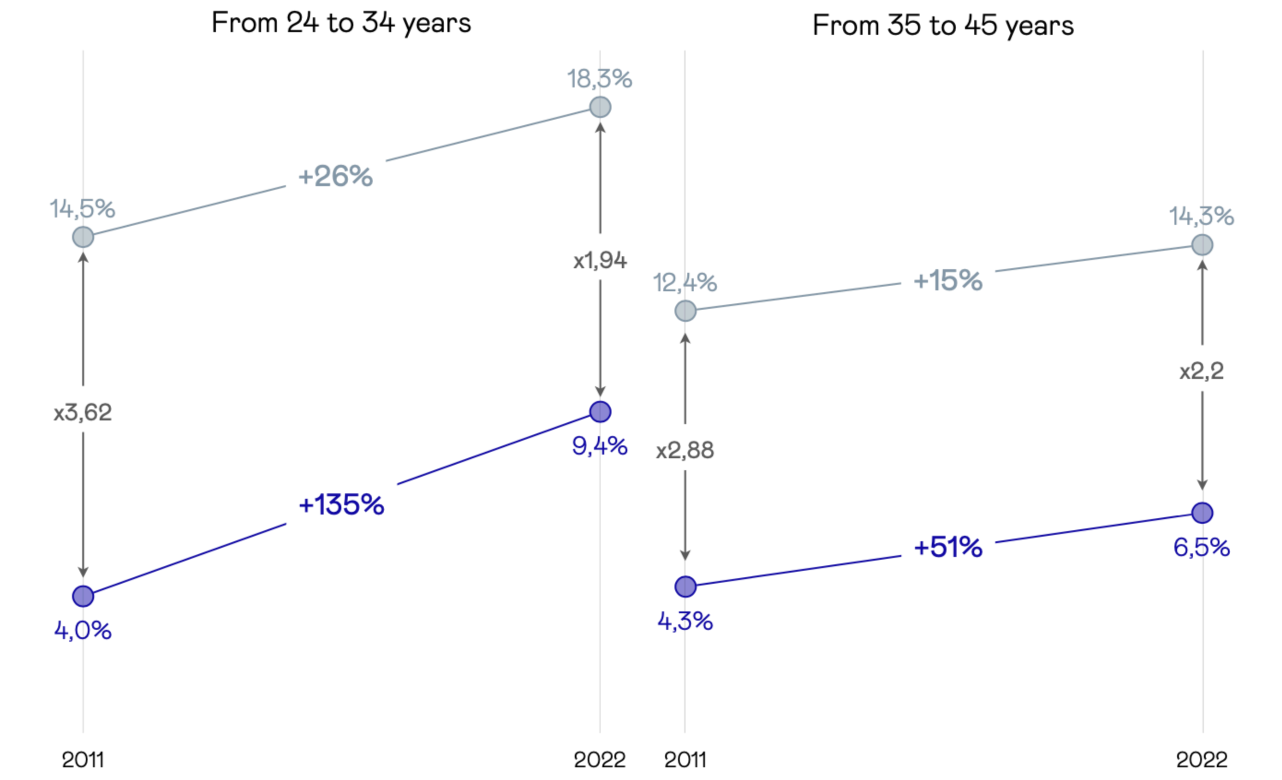
Figure 19. **Percentage of women and men in STEM occupations in each age group** · 2022



Source: Living Conditions Survey (2022) | EsadeEcPol
Only those occupations for which there is a sufficient statistical sample are included.

The improvement of the younger age segments in the percentage of women and men in STEM occupations in recent times is remarkable. We begin by analyzing the age bracket that coincides with the end of the vast majority of higher education careers: 24 years of age. We extend it to 34, leaving a decade to reflect the consolidation of the first stage of most professional careers. We also observe how a second group has changed: the 35-45 year-olds, a time when the consolidation of employment and child-rearing tend to converge. It turns out that the STEM occupation rate among women aged 24-34 has doubled. A much more substantial growth than that seen for the entire series, and higher than the immediately preceding generation. Increases for men also exist but are always smaller in magnitude.

Figure 20. **Increase of the percentage of women and men in STEM occupations in each age group**



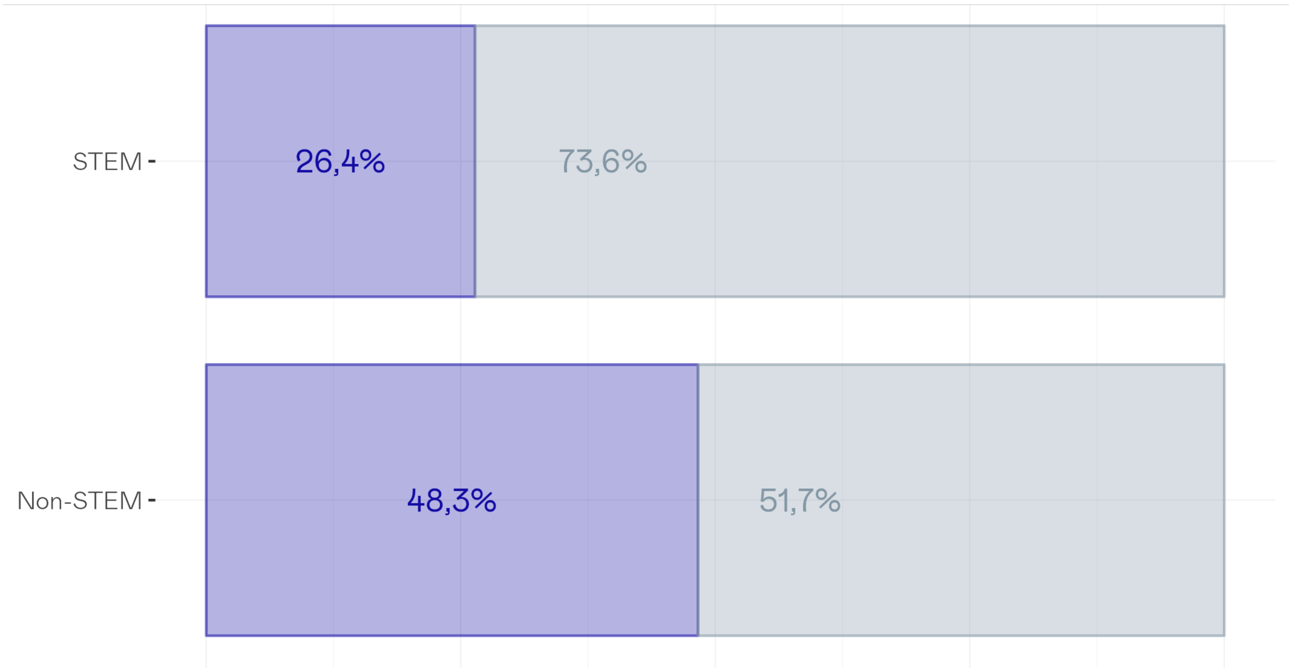
Source: Living Conditions Survey (2022) | EsadeEcPol

STEM occupations, professions with a low presence of women

With the differences observed in these percentages[11], it is not surprising to see that, i**f the total number of STEM positions is divided by gender, only one in four is occupied by a woman.** This contrasts sharply with the fact that non-STEM occupations are evenly split between the two genders, so the gap is similar in size to what we are already beginning to see in vocational and higher education.

[11] It is worth noting how these percentages contrast with those obtained with other approaches. The Ministry of Science (2022) measure that classifies as Human Resources in Science and Technology (HRST) any employed person who has completed post-secondary education (levels 5 to 8 of the National Classification of Education) or who is employed in a professional (CNO11 group 2) or technical (CNO11 group 3) position yields 34,1% of women employed as RHCT versus 28.4% of men, a very different picture from our (notably more demanding) classification not only because it multiplies the volumes, but also because it changes the apparent relative proportion between men and women.

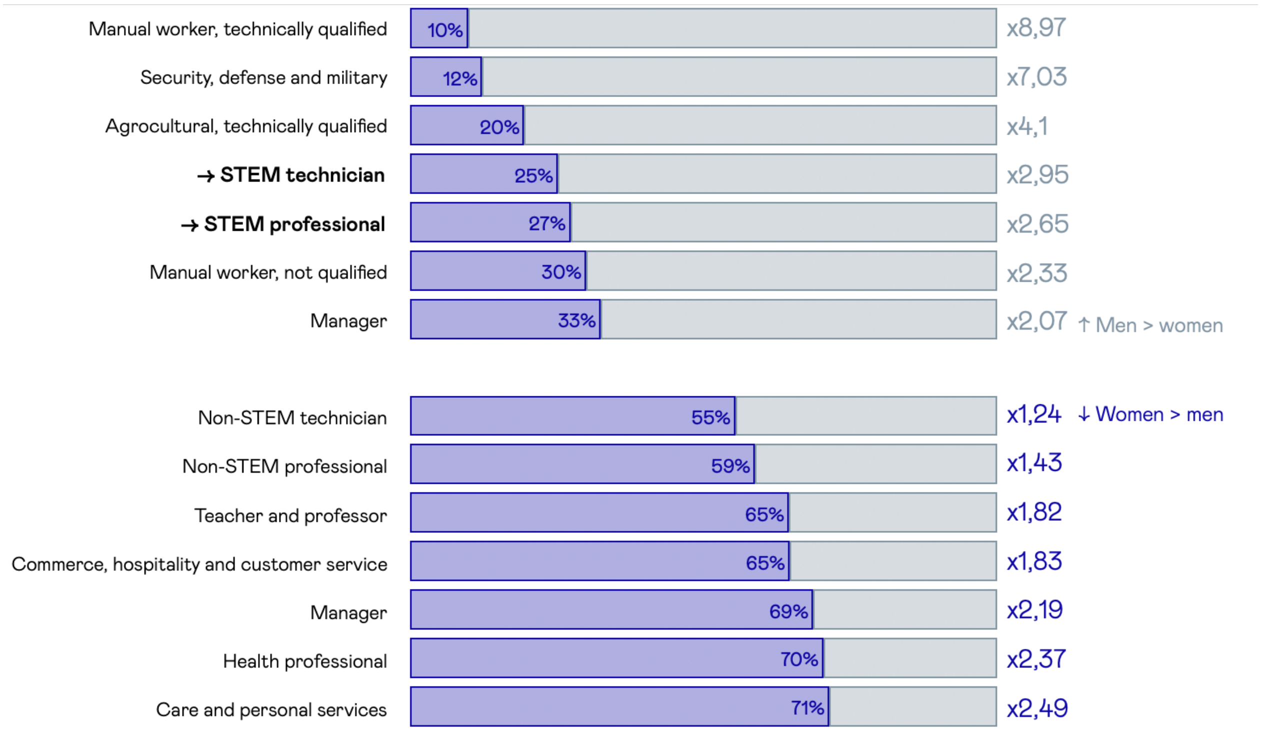
Figure 21. **Distribution of STEM and non-STEM occupations between women and men** · 2022



Source: Living Conditions Survey (2022) | EsadeEcPol

These differences are very similar for technicians and STEM professionals, although it is worth noting that they are not the most relevant among the classification of occupations: positions in skilled and unskilled technical manual labor are still more masculinized. In contrast, the occupations of technicians and non-STEM professionals, as well as those of health and teaching professionals, are notably more feminized.

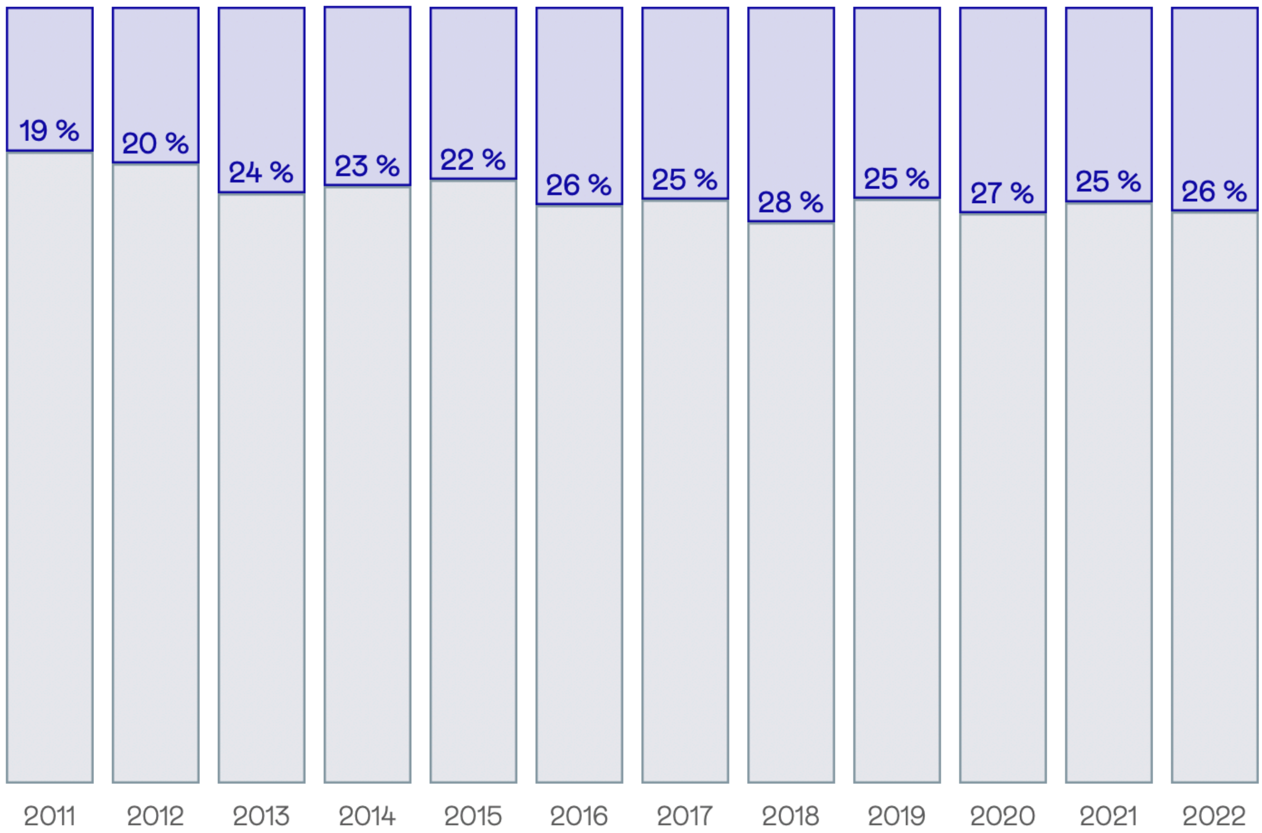
Figure 22. **Proportion of men and women in each occupation** · 2022



Source: Living Conditions Survey (2022) | EsadeEcPol
*Only those occupations for which there is a sufficient statistical sample are included.

It is particularly striking that **this 3/1 ratio against women in STEM occupations has remained constant over the last decade.** It should be clarified here that the LCS does not completely renew its sample each year: all the households that make up the sample spend four years responding to it, so that in reality each year changes by 25% with respect to the previous year. This means that changes are perceived more slowly, but the absence of changes is notable.

Figure 23. **How the distribution of men and women in STEM occupations has evolved**



Source: Living Conditions Survey (2022) | EsadeEcPol

Women with STEM backgrounds who end up in other occupations

These labor gaps seem to widen those we were already seeing in the formative phase. The 2019 Labor Market Insertion Survey of University Graduates (latest year available) allows us to specifically answer the question of what STEM degree graduates were doing in the 2013/2014 academic year five years after graduation (as we defined them in the previous section). Applying our classification of occupations, we observe that it is relatively less common for a female STEM degree holder to be a STEM professional than a male STEM degree holder, and much less common for her to be in a managerial position. She is more likely to be a professor or teacher, an administrator, or a technician in a non-STEM area. For STEM technicians there are no appreciable differences.

Figure 24. **What occupations STEM majors graduates go into five years after graduation** · 2019

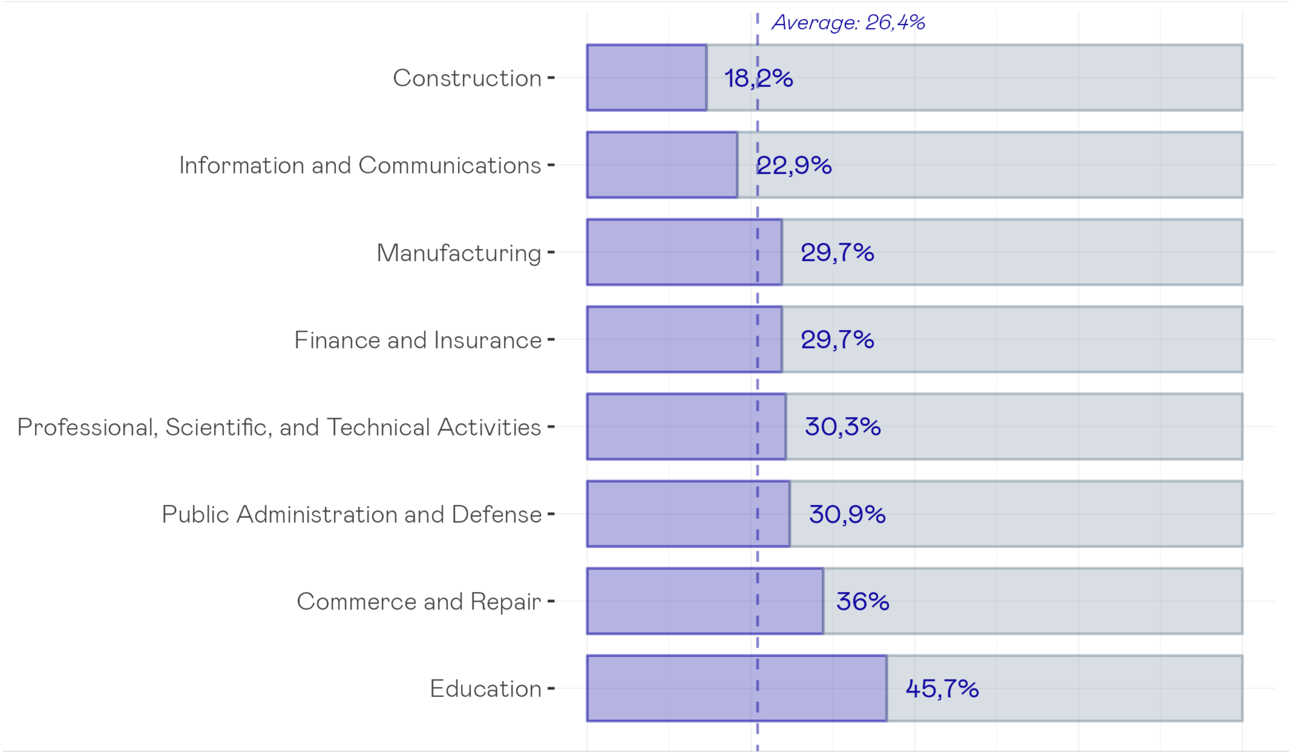
	Men	Women	Difference
→ STEM professional	**46,2%**	**39,8%**	**x1,16**
→ STEM technician	**16,4%**	**16%**	**x1.02**
Teacher and professor	7,3%	11,8%	x1,62
Manager	6,2%	3,7%	x1,68
Non-STEM professional	5,5%	5,6%	x1,02
Clerk	3,9%	5,3%	x1.35
Non-STEM technician	4,7%	6,7%	x1.42
Others	9,8%	11,1%	x1,13

Source: University Graduates Labor Market Insertion Survey (2019 | EsadeEcPol
*Se incluyen solo aquellas ocupaciones para las que hay muestra estadística suficiente.

Specifically, **Specifically, women who have completed a STEM degree are around 2.7% less likely to work in a STEM occupation than their male counterparts.** These estimates are derived from a more demanding regression analysis, which takes into account baseline characteristics for women and men such as the university where they studied, age, or sector of activity, and produces this statistically significant difference. The gross gap, before discounting all these factors, is higher: 6.7%.

When we turn to the sectoral perspective, STEM occupations have a much lower proportional presence of women in construction and ICT, both below the overall average. In manufacturing, professional, consulting, financial or finance and insurance activities, it is between 29% and 36%. In contrast, education is the activity in which the male-female distribution of STEM occupations is the most even, although even in this case they do not reach a majority. This reflects the trend we were already seeing among younger girls to prefer or choose the education route, a traditionally feminized profession (according to the Labour Force Survey at the close of 2023, two-thirds of the education sector was occupied by women).

Figure 25. **Percentage of women and men in STEM occupations by sector** · 2022



Source: Living Conditions Survey (2022) | EsadeEcPol

Evidence · Factors behind the gap in STEM Occupations

The fundamental mechanisms to explain the lower presence of women in STEM occupations are to be found in the pre-career stages, as we have seen in the sections devoted to education. However, there are additional factors that are activated or deepen during the professional career that are worth mentioning here.

Confirming the evidence dumped in our analysis of the EILTU for Spain, according to a more detailed study from the time-tracking of STEM graduates in Germany, female graduates, in general, have a smaller advantage in the transition to STEM occupations during the first five years of their working career compared to male STEM graduates; an effect that is more pronounced for engineering and computer science graduates (Schwerter and Ilg, 2021).

Looking for specific mechanisms, the same study notes that when women have children before graduation (not after), this helps explain the difference. Focusing on the effects of motherhood, a study tracking the careers of working women and men in the United States finds that 43% of mothers (versus 23% of fathers) leave full-time employment in STEM after their first child, and those who remain in the full-time labor market are more likely to leave STEM to work in other fields (Cech and Blair Loy, 2019), something observed by other studies (Kahn and Ginther, 2015) that also explore additional mechanisms, such as a gap in the higher dropout rate explained in considerable part by the greater propensity of women in engineering to leave as they are dissatisfied with opportunities for salary and career growth (Hunt, 2016).

An additional factor could be the intensity of mathematics presence in training: a detailed study using data from Purdue University graduates (with a focus on science and technology) found that "part of the gender gap in STEM career dropouts can be attributed [to the fact that] women are more represented in less mathematically intensive careers. In addition, graduates in less mathematically intensive STEM careers are more likely to adapt and accept jobs in non-STEM occupations" (Jiang, 2021). This evidence connects with what was observed for Spain in the section on education, according to which the grading gap was especially deep in mathematics compared to other sciences, and the presence of women in math-intensive careers is low or declining; facts that, in light of the possibility of penalization later in working life, also invite concern.

The effect of a STEM occupation on gender employment gaps

In Spain, women in professional or technical STEM occupations face a wage gap significantly lower than the average, and significantly lower than their professional and technical equivalents in non-STEM fields. The 2022 LCS data indicate that the largest wage gap[12] is among professionals outside the STEM world, including health care, managerial positions, and manual workers: in all cases, men's salaries are at least 1.2 times those of women. While the average gap is x1.20, that of STEM professionals and technicians is x1.1 and x1.08, respectively: it still exists, but to a lesser extent.

[12] In gross monthly salary by occupation for people with full-time positions.

Figure 26. **Average salaries of women and men by occupation, and the ratio difference between the two** · 2022 · in thousands of euros gross per month.

	Men	Women	Ratio
Non-STEM professional	**2,8K**	**2,2K**	**x1,28**
Non-STEM technician	**2,1K**	**1,7K**	**x1,28**
Manual worker, technically qualified	1,6K	1,3K	**x1,22**
Manual worker, not technically qualified	1,3K	1,1K	**x1,21**
Health professional	3,2K	2,7K	**x1,21**
Commerce, hospitality, and customer services	1,5K	1,2K	**x1,20**
Manager	3,4K	2,8K	**x1,20**
Average	*2,1K*	*1,8K*	*x1,20*
Care and personal services	1,2K	1K	**x1,16**
Teacher and professor	2,6K	2,3K	**x1,16**
Clerk	1,9K	1,7K	**x1,14**
STEM professional	**2,6K**	**2,4K**	**x1,10**
STEM Technician	**2K**	**1,9K**	**x1,08**
Security, defense y military	2,1K	2K	**x1,04**
Agriculture, technically qualified	1,2K	1,4K	**x1,15**

Source: Living Conditions Survey 2022 | EsadeEcPol
*Se incluyen solo aquellas ocupaciones para las que hay muestra estadística suficiente. Los salarios son para ocupaciones a tiempo completo.

At the same time, **women in a STEM field are less likely to end up in part-time employment, with a significantly smaller gap with men than in non-STEM occupations.** Again, according to data from the 2022 LCS, being a woman increases the probability of working part-time by 17 percentage points, but having a STEM occupation decreases it by 6,6%, according to an analysis based on a multifactorial probabilistic model in which we put both factors (gender and STEM occupation) in interaction to distinguish the combined effect. The result: women in STEM fields are less likely to work part-time than would be expected by simply adding the effect of being a woman and working in a STEM field. The combination of the two is associated with a 12,8% lower probability of working part-time; and these points are additional points over the separate sum of the two factors.

Figure 27. **Percentage of men and women with part-time contracts by occupation** · 2022

	Women	Men	Ratio w > m
STEM occupations	**8,22%**	**3,27%**	x2,51
Other occupations	26,29%	9,37%	x2,81

Source: Living Conditions Survey 2022 | EsadeEcPol

This is particularly relevant in a country in which not only does the percentage of women with part-time contracts tend to triple that of men, but in which 47.6% of women with part-time contracts claim to be part-time because they have not found a full-time option, according to the EPA at the end of 2023. It is true that the lower aggregate part-time rate, without distinguishing between the sexes, could indicate a lower supply of this type of position for STEM occupations. And, to the extent that women tend to have a higher demand for labor flexibility (precisely to reconcile with family life, among other factors), some voices in economic research have argued that this could be an explanatory factor in the dropout data for STEM trajectories (see, for example: Kahn and Ginther, 2015). Without entering into this debate, which is impossible for us due to the lack of sufficiently detailed data, we can point out that what is significant in the analysis presented here is not so much the lower incidence of bias in STEM vs. non-STEM occupations, but the smaller gap between men and women.

Evidence · **A potential award for being engaged in STEM**

Supporting what was seen for Spain in our analysis, **STEM occupations are associated with a wage premium that even exceeds that which normally exists for simply having a higher level of education** (OECD, 2022), although it is true that this premium varies between countries, fields and educational levels within the STEM field (Even et al, 2023). Wage growth in European countries could even be slightly higher for women than for men: up to 0.6 points (Sánchez-Mangas and Sánchez-Marcos, 2021), although the authors of the study point out that "it seems to be due to the higher wage growth of women without children", completing the evidence already seen above. However, there is no wage penalty in STEM for women with children as there is in the workforce as a whole, driven by professionals in the fields of business administration, business, economics and law. This same work also notes for women in STEM in Europe a slightly higher rate of hours worked per week than in all other fields, although a significant gap remains on this front indicating that men work longer hours, as also exists in months of tenure (where the situation is, in fact, worse than in other fields). Other studies for the United States indicate that the likelihood of women leaving the labor market is lower in engineering than in other careers, and lower for single women without children than for men (Kahn and Ginther, 2015).

Ideas and proposals to close the gaps

The gender gap in STEM appears at an early age in the form of self-confidence, mathematical anxiety, affection and, therefore, lower results in mathematics, which are reflected in expectations far removed from scientific-technological fields as early as 15 years of age. Furthermore, this gender gap, far from narrowing, widens throughout the educational stage, resulting in a lower selection by girls of STEM fields both at university and in vocational training, despite obtaining comparable educational results. The lower proportion of women in STEM studies has, as is logical, consequences in the labor market in the form of lower participation in occupations and sectors related to STEM fields that, in addition to being booming (Cedefop, 2015; UNESCO, 2021), present above-average working conditions (Joensen and Nielsen, 2016; ILO, 2019). The evidence leans towards traditional gender roles and lack of role models as motives underlying the most incipient disparities, which perpetuate a vicious cycle that not only deprives women of job opportunities in fields with good conditions, but also deprives society of having role models to inspire new generations. Once we have found, at least in part, the diagnosis, we must ask ourselves: what can we do to mitigate these gaps?

Progress towards a more inclusive education system

As in so many other areas, the answer begins in early education, where the first gaps originate, but also the first opportunities to alleviate them, being much more difficult to correct biases once they are already in place. Education is key to making scientific careers attractive and accessible to boys and girls and, above all, for the latter to develop a positive self-image of their abilities. Curricular rigidity, lack of pedagogical tools in the classroom, and insufficient reinforcement, accompaniment and guidance are structural problems of our educational system that harm all types of students. Tackling them would not only benefit all of them but could also have a significant impact on favoring the participation of female students in STEM subjects. Within this general framework of necessary improvement for different groups at a disadvantage from the outset, we explore here three ways to do so with the emphasis of this report.

Additional and extracurricular training in STEM areas

→ **Encourage participation in STEM areas** through courses, extracurricular or summer activities, also seeking to activate mechanisms of self-confidence, self-perception and affection towards mathematics

The causal evidence on the impact of science education from an early age is scarce, but shows very positive results. In primary education, the results of a randomized controlled experiment with more than 1,000 eight-year-old students show that the use of an application with STEM content increases the interest of girls, and not their male counterparts, by scientific-technological branches (Grosch et al., 2022). The app not only addresses direct interest in STEM through games and activities, but also addresses already mentioned behavioral mechanisms such as confidence or competitiveness by introducing, for example, female scientists as role models in the app. They find that the gain in self-confidence is the main mechanism through which the app increases affection for STEM areas.

In secondary education, the evidence also shows positive results of after-school activities and courses to foster an affection for science. A recent example is Cohodes et al. (2022), who conduct an experimental evaluation of summer STEM programs for underrepresented youth in these fields, including a six-week program, a one-week program, and online training. They find that the programs do indeed increase the attainment of college degrees in STEM fields, which could increase potential student earnings by 2% to 6%. They also reduce dropout during college, and the one-week program especially increases STEM graduation for girls.

Numerous programs related to STEM fields are promoted in the United States and can serve as inspiration for other countries. The existing evidence shows promising results, although not conclusive. Some examples of programs are: the “Girls Who Code” program, which reports that the likelihood that girls are more likely to participants study computer science in college is 15 times higher than the national average (Girls Who Code, 2019); and FIRST, which is a research and robotics community open to students from kindergarten through high school, whose participants are much more likely than the national average to study engineering (Burack et al., 2019). Other related programs include Boys and Girls Club of America or Girls Scouts in STEM.

In addition to these third sector initiatives, in some European countries the public sector is allocating resources to promote programs that encourage the participation of young girls in STEM. These include the "Girls and Technology" program in Norway, active since 2003, and a recent initiative in Ireland that allocates public funds to more than 40 STEM projects.

Flexible, tailored and unbiased curriculum and materials

→ **Eliminate biases in the curriculum and materials**, making them more flexible and adaptable to the needs of all students, achieving more inclusive educational models and content.

Increasing the weight of science in the curriculum is undoubtedly a good starting point. However, if it is not done from a gender perspective, focusing on the mechanisms that discourage girls' participation in the scientific-technological field, the results may not be as expected. For example, the analysis, using quasi-experimental techniques, of the adoption of a measure in the United Kingdom that gradually increased the number of hours of science taught in secondary schools, concluded that that this policy increased the number of boys enrolling in STEM degrees, but had no impact on the number of girls enrolled (Phillippis, 2021).

Sweden is a clear example of progress on gender in schools, where there are *gender neutral schools*, which are educational centers that follow a pedagogy that seeks to eliminate traditional gender distinctions and stereotypes, using inclusive language, neutral toys and activities, neutral infrastructure and resources, and equal representation. Although causal evidence of the impact of these centers on gender stereotypes is not yet available, one study compares students enrolled in these schools with students enrolled in non-neutral centers and finds substantial improvements: boys in "neutral centers" play more with girls they do not know and score lower on measures of gender stereotypes (Shutts et al., 2017).

Another important issue related to the curriculum is the underrepresentation of women in books and materials. Recently, an interesting study has been published using artificial intelligence to characterize the representation of children's books in homes, schools, and libraries over the last century (Adukia et al., 2023). The authors find that, although females are increasingly present in book images, they appear less frequently in texts, suggesting greater symbolic inclusion. In addition, it appears that the demand for books is related to consumers' personal and political beliefs (which, according to the authors, may mean that the type of books parents choose for their children influences the transmission of gender beliefs). For its part, another analysis shows, albeit with weak evidence, a relationship of female representation in textbooks with science scores and math anxiety (Good et al., 2010). In addition, through a small experiment they reveal that counter-stereotypical images have a positive impact on female students' performance, thus alleviating the gender gap.

Inclusive, individualized, and collaborative teaching tools

→ **Provide teachers with teaching tools** to generate an inclusive, individualized, dynamic, collaborative STEM education, focused on joint scientific-mathematical problem-solving, and that minimises biases.

As we detailed above, the teacher's own gender affects the affect and efficacy of female students in science and mathematics regardless of stage (Bettinger et al., 2005; Carrel et al., 2010), but the teacher's treatment and beliefs about students' ability have a substantially greater impact on their performance and choice of future pathways (Sansone, 2017; Lavy and Sand., 2018). Teachers show important biases that have implications: according to qualitative research (Hand et al., 2017), they attribute more male characteristics to scientists and female characteristics to other areas such as humanities, and believe that boys perform better in STEM disciplines.

In order to eliminate these stereotypes and traditional roles associated with scientific disciplines and change these dynamics, it is essential to equip teachers with the necessary teaching tools to deliver gender-inclusive STEM education. The first step is likely to be for teachers to recognize their own biases when they exist. To this end, the *Conseil du statut de la femme* (Quebec governmental institution) created an online questionnaire that allows the teacher to be aware of whether or not his or her teaching method reproduces these behaviors and promotes gender equality.

An interesting example of an innovative teaching methodology aimed at reducing the gender gap in mathematics in Primary Education was evaluated through a randomized controlled trial with 1,044 students (Di Tommaso et al., 2020). The methodology consists of 15 hours of trainings emphasizing peer interaction, exchange of ideas, student engagement, problem solving and problem formulation. This methodology significantly increased girls' math performance, without impacting that of boys, thus reducing the gender gap. This suggests that innovative methodologies, as well as inclusive language and equitable expectations, curriculum and materials that ensure female representation or even with specific interventions such as this one aimed at getting girls to increase their interest and confidence in STEM, can have a strong impact.

Accessible, sufficient and quality guidance

→**Provide individualized counseling** to support decision making and to ensure that no one is left out of a potential choice to undertake specific STEM training for lack of appropriate guidance at the right time.

The lack of investment in academic-vocational guidance at all educational stages in Spain is a structural problem that can affect, among other things, the choice of modalities. A large proportion of students in ESO, Bachillerato and FP are not trained in STEM fields because they have not received guidance and information on these areas (DigitalES, 2019), being at this age the orientation at school the main academic-professional guidance (Rossi y Barajas, 2015).

The public sector should be a first guarantor that all students have access to sufficient and quality guidance in their schools. In addition to increasing the number of guidance personnel, in other countries, such as Germany, the public sector supports initiatives that can serve as an illustration: Komm-mach-MINT ("Come do STEM")[13], is an online platform that aims to support girls and women in their choice of studies and careers, a program whose effects have not yet been evaluated.

In this regard, initiatives by private companies and the third sector are also emerging : the "Impacto STEM " (Educar en Igualdad, 2022), project in Spain which consists of training school guidance counselors to promote effective and inclusive vocational guidance strategies, through non-stereotyped guidance, the provision of practical resources to enhance it and a technological tool that facilitates guidance in 3rd and 4th grades of ESO (middle School).

Role models and training to encourage female participation in STEM

The lack of female role models in STEM fields tends to perpetuate the shortage of female role models for future generations. This lack of concrete and associable role models is palpable in all educational stages and at all levels and, as shown above, has a negative impact on self-perception, confidence, and academic and professional expectations in STEM areas. Direct access to these role models at school, at home and in other non-formal educational and professional environments can be a determining factor in girls' decision-making at key moments in their educational and professional careers.

[13] For more information: https://www.h-brs.de/en/komm-mach-mint

Role models: the impact of female role models

→ **Increase access to role models** for girls through mentoring, master classes, and other forms of direct access to women currently in STEM roles at crucial times for educational and career decision making.

The evidence shows that the presence of mentors has a positive impact from Elementary School through College, both on self-perception, confidence, and affection for mathematics and on enrollment in STEM degrees. Moreover, most of these interventions are low-cost and have significant magnitude effects.

One of the initiatives for younger students has recently been evaluated, with an experimental design, in Spain (González-Pérez et al., 2020): "Inspiring Girls"[14], in which female workers in STEM fields volunteer in schools from 6th grade of Primary Education to 2nd year of ESO to talk about their professional careers. The results suggest a positive impact of this intervention, which improves girls' beliefs about their ability to succeed in STEM fields and increases the likelihood that they will want to choose a STEM career. It also impacts positively on their enjoyment of mathematics, the importance they attach to it, and their expectations, and negatively on gender stereotypes. In fact, interestingly, the greater the counter-stereotypical nature of the sessions, the greater the relationship between expectations of success in mathematics and STEM choice.

The evaluation, also experimental, of L'Óreal's "For Girls and Science" program in France goes a step further, measuring the impact on enrollment in STEM degrees (Breda et al., 2021). In this case, a single-session exhibition involving, on a voluntary basis, 56 female scientists and nearly 20,000 male and female 4th ESO and 2nd High School students positively impacted female students' perceptions of science careers and increased girls' enrollment in STEM university degrees (but not boys'). This occurred only for higher-achieving female students and in those grades with greater gender imbalance (more intensive in mathematics). Finally, the results suggest that the most effective interventions were those that sought to improve the perception of STEM careers without overemphasizing the underrepresentation of women in science.

Female role models in higher education continue to have a positive impact on STEM affect and outcomes. The results of the evaluation of a natural experiment in an engineering university point out that having a female assistant professor has a positive impact on subject grades and on the probability of choosing a subject of "higher difficulty" and, moreover, this impact is greater when there are more female classmates in the classroom (Griffith and Main, 2021). Along the same lines, another study presents robust experimental evidence with a positive impact on the choice of itineraries, but in this case, for Economics (Porter and Serra, 2020).

[14] For more information: https://www.inspiring-girls.es/

Families' awareness

→ **Raise awareness among families** by increasing exposure to mathematical concepts at home from early ages and promoting parental involvement in mathematics learning processes.

As we have seen, gender roles play a fundamental role in the mathematics outcomes of boys and girls, operating not only at school but also at the household level, where the attitudes and expectations of families shape their children's confidence, interest and, therefore, outcomes in these areas (Dasgupta and Stout, 2014; Dossi et al., 2020). We also know that starting early with mathematics instruction is beneficial for the development of these skills in children. However, although these skills are increasingly taught in formal early childhood education settings, exposure of young children to mathematical concepts is less frequent at home (Mayer et al, 2023).

Several recent studies have sought to evaluate the effectiveness of initiatives that seek to foster learning environments in the home. In particular, behavioral economics has made it fashionable to use text messaging interventions to promote family behaviors that improve children's educational outcomes, albeit generally with literacy-related skills. However, a recent study also examines whether programs of this type, but focused on mathematics, might be effective (Doss et al, 2022). What is more is that they find that math programs only have detectable (and differential effects on girls) when combined with literacy and social-emotional learning programs, perhaps because this encourages the participation of parents who, faced with a program focused only on math, may suffer from math anxiety of their own.

Another experiment highlights improvements in children's math scores as they increased their exposure to math concepts at home through digital applications (Mayer et al., 2023). Surprisingly, although these apps allowed children to learn on their own without parental intervention, their use also significantly increased parental involvement in the learning processes.

Bootcamps: straddling the gap between formal education and the labor

→ **Incentivize access to *bootcamps*:** intensive training programs to acquire specific STEM skills, especially for women with a worse position in the labor market due to their low qualifications.

Both for people already active in the labor market and for those who have not yet entered, but want to complete their training, bootcamps are an increasingly appealing idea. Bootcamps are intensive training programs, usually lasting half a year maximum, designed to acquire specific skills — usually related to ICT (programming, web design, data analysis...) in a short period of time.

In Spain, *bootcamps* are still in a preliminary phase. Most of the people enrolled are private individuals (82%) and they tend to be oriented towards young people: only 25% of the students are over 35 years old, and almost 90% are web developers. Regarding gender, it is encouraging that in 2020 36% were women, because, although it is a lower percentage than desired, it is well above the female weight in total ICT employment, which stands at 16% according to Eurostat. For all these reasons, bootcamps are undoubtedly a desirable alternative for women without STEM training who wish to acquire skills that will enable them to access positions with better working conditions, as well as for women who want to update their digital skills.

The evidence regarding the impact of this non-formal training on employment in STEM fields is practically non-existent, especially for the case of Spain. A randomized controlled experiment in Argentina and Colombia with women already participating in the labor market finds that the courses -mainly in programming- have a strong impact on the skills of the participants, also impacting positively on the probability of finding a job in the technology sector, the main mechanism being this improvement in skills (Aramburu and Goicoechea, 2021).

Currently there are several initiatives that offer *bootcamps* (such as LaunchCode) and some that focus on women (such as Girls in Tech, or Techladies) that, in addition to offering non-formal training, provide a space to meet women in the technology sector, providing not only technical skills but also support networks.

Labor policies to ensure the incorporation and permanence in STEM occupations.

Gender gaps in STEM fields emerge in the early stages and continue throughout the educational process and, therefore, it is in the most incipient stages where actions must begin to try to reduce these disparities. However, in order to try to achieve greater participation of women in scientific and technological occupations, it is necessary to face continuous labor challenges that, in some cases, are specific to STEM fields and in many others are common to other fields (lower participation, greater temporality and lower salaries, among others). Although there are women who voluntarily choose to abandon scientific careers, many others do so because of the scarcity of work-life balance measures and cultures that are not very inclusive. Therefore, a change in the structure and culture is necessary to attract, retain and advance women in STEM fields (UNESCO, 2024).

Inclusive environments, support groups and collaborative networks

→ **Fostering an inclusive work environment** to reverse the gaps by two ways, changing younger people’s view of STEM occupations and reducing the dropout of women already in STEM occupations.

The impact of “peers” is not only relevant at the educational stage (Fischer, 2017; Brenøe y Zölitz, 2020), but also has an impact on the labor market. That STEM occupations are male-dominated and the lack of role models are identified as some of the reasons for women's low preference for scientific-technological occupations (Cherayan et al., 2019).

Women in STEM report high levels of isolation, difficulties in gaining respect, and strong gender stereotypes (Seron et al. 2016). Meanwhile, another study estimates that nearly one-third of women leaving STEM occupations cite an unwelcoming culture as a key factor (Fouad et al., 2017). Along the same lines, results from a fieldwork with STEM professionals point out that women experienced a greater threat to their social identity (or belongingness) on days when they have conversations with men and feel low acceptance, an effect that is not observed in either case for men or women when having non-work-related conversations (Hall et al., 2018).

These experiences point us in a clear direction: fostering an inclusive work environment is paramount to reversing the gaps in two ways, by changing younger people's view of STEM occupations and reducing the dropout of women already in the labor market. There is interesting —albeit descriptive— evidence in this regard: using longitudinal data on modifications in gender-inclusive practices with a sample of male and female engineers, they find that they are related to greater organizational commitment only in women (Hall et al., 2021).

To foster this inclusiveness, as in the early stages of education, mentoring, role models and support groups are tools that can act as facilitators, reducing dropout and encouraging promotion. An interesting case is that of Sanofi SA, in the United States, a company in the STEM field that implemented a senior management training program focused on women to increase the proportion of women in management positions. Although the evidence is merely descriptive, a six-month leadership and mentoring program was associated with a higher proportion of women promoting to senior positions (Kong et al., 2020).

In addition to training or mentoring, although the evidence is not sufficiently robust, support groups and collaborative networks have the potential to generate a more inclusive environment, fostering the social identity of women in male-dominated sectors. Initiatives such as "Empowered Tech" (which seeks to support women in technology-related occupations through face-to-face and online meetings, workshops and roundtables) as well as "Women in Data" are benchmarks in this area and also provide a good framework for experimental evaluations to help us understand the impact of these types of initiatives on the incorporation and progression of women in scientific-technological careers

Conditions for women's career progression in STEM

→ **Ensure policies that support equal opportunity access to** STEM career progression: with equal work' life balance for men and women, equitable pay and promotion systems, and well-specified standards.

STEM jobs in Spain offer, as we have seen above, higher salaries. They also enjoy better future prospects: in fact, according to our LCS analysis, the share of STEM occupations as a total percentage of the labor force has grown since the middle of the last decade. At the same time, they have a lower proportion of part-time jobs. And they tend to require a higher-than-average level of education. All this points to a segment of the labor market that is dynamic and competitive, but where (precisely because of this) the opportunities for job progression are at the same time considerable. Therefore, it makes sense to focus on policies that facilitate women's access to these opportunities on an equal footing. These measures are not necessarily specific to the STEM field, but are cross-cutting in nature because inequality of access to career advancement opportunities is also cross-cutting. But they do seem a necessary condition for moving towards a more equal presence of women in STEM beyond education and the beginning of the work journey. We highlight three:

- **Access to and use of work-life balance instruments**, such as paternity and maternity leave, can favor women's career progression as long as it is ensured that the use of these options converges on the part of men, to avoid that due to self-selection bias women use them more often and end up spending less time than men on their careers (Kong et al, 2020). Indeed, policies that focus exclusively on mothers tend to reinforce, rather than challenge, conventional stereotypes about gender roles and gaps in the workplace (Aumaitre, 2016).

In Spain, the current leave for birth and/or adoption is 16 weeks and, from 2021, equal and non-transferable for each parent, which places us as a pioneering country worldwide and would favor, in principle, a more shared parenthood and, therefore, a more co-responsible work-life balance. Indeed, a recent study finds that this equalization policy has slightly reduced the gender gap in hours worked, as women who remain in employment reduce their working hours to a lesser extent after the equalization of leave (Gorjón and Lizarraga, 2024). However, the measure also seems to have reduced the probability of remaining employed for both men and women, and to a greater extent for the latter, so that the gap in labor participation has not been closed with the reform. Therefore, in order to move towards a truly shared work-life balance, it is necessary to design these leaves in such a way as to encourage both parents to make equal use of them, and to accompany them with an infrastructure that supports them. This includes, but is not limited to, access to free, quality 0-3 education, efficient transportation options, as well as flexible work policies that recognize and adapt to the needs of workers with family responsibilities.

- **Remuneration and promotion systems with gender-neutral results**, that avoid the biases that have traditionally affected women in the workplace, especially in sectors such as STEM. In order to implement effective policies in this regard, it is essential, firstly, to achieve wage transparency, guaranteeing access to detailed and representative information on company wages, ideally at the census level. Several countries already require companies to make this information public. Thus, since 2017, the largest companies in the United Kingdom have been required to disclose their salary and bonus structures, including the gender distribution in these remunerations and in each salary range. Similar measures have also been implemented in countries such as Germany or Iceland, where companies must not only publish this data but also undergo independent audits to demonstrate that they offer equal pay (Kong et al, 2020). Following this tendency, the European Commission gave the green light in 2023 to the new Pay Transparency Directive, whose central objective is to promote pay equity between male and female workers performing jobs of equal value. This Directive provides for a transposition deadline of June 2026. Therefore, it is still too early to know how it will be implemented in our country, but we are undoubtedly facing a good opportunity to design this policy so that it effectively materializes in tangible wage equality.

- Finally, it is worth noting that **the design of these or other anti-discrimination standards must be sufficiently specific, non-interpretable, and based on nuanced evidence.** - As suggested by Kong et al (2020), when the rule aimed at reducing gender discrimination is excessively ambiguous or open-ended, or when there are no mechanisms to enforce it, it is more likely that reality will deviate from the rule, even if it exists. Rather than defining a rule for each possible trap, it is a matter of rigorously assessing what effect it has once it is applied, in order to adjust it according to the possible lack of desired effects or the presence of undesired results.

Methodological Annex

The vast majority of studies that exist on the presence of women in STEM focus on the university or research environment and use the content of the studies pursued (or the research conducted) to differentiate who would fall into or out of the STEM category. Inferring from it who is engaged or would like to be engaged in STEM occupations exposes the analysis to under- or over-estimate the size of this group. On the one hand, it biases the results to people with college degrees (Rothwell, 2013). On the other hand, extrapolating that everyone with STEM training has ended up in a STEM occupation prevents us from observing whether there is any kind of mismatch between what has been studied and what has been put into practice. In a labor market such as the Spanish one, in which the mismatch between supply and demand tends to disadvantage those profiles with a higher level of education (OECD, 2022), this risk is especially significant.

This makes it particularly relevant to carry out a separate analysis by occupation, something that in any case is fundamental for answering the questions set out in the corresponding section. Theoretically, the most detailed possible way to answer these questions would be to start from the tasks that make up each job and the skills that are required to perform them. . Qualifications can be anchored in previously acquired training, but skills or tasks need to be collected with ad hoc surveys. The US database O*NET (Occupational Information Network Data Collection Program) is an example of a source that enables this comprehensive approach, allowing, for example, occupations to be classified according to STEM skill intensity: Rothwell (2013) is a pioneering and prominent example.

However, to the best of our knowledge there is no equivalent database in Spain, so analyses of STEM penetration in the labor market usually refer to training; the sectors of activity in which each job is performed, specifically the National Classification of Economic Activities (CNAE); or the one-dimensional classifications of occupation, specifically the International Universal Classification of Occupations (CUIO or ISCO-08) established as the European standard since 2008, and the 2011 National Classification of Occupations (CNO11). Both CUIO and CNO11 follow a nested logic: a first level of major groups that in turn contain second, third and fourth levels of detail. These are the reference categorizations in the data sources that could allow us to deeply analyze the distribution of women in jobs that could be considered STEM.

The challenge lies in choosing a combination of categories and sources that allows us to obtain data that are both informative and statistically representative. There is a dilemma between the two: the lower we go in the level of disaggregation of the classification, the more informative resolution we gain, but the greater the risk of ending up with analyses based on insufficient samples.

Of the three reference sources for analyzing the dynamics of the labor market in Spain (data from the Social Security, the State Employment Service, and the INE's Labor Force Survey), the EPA is the only one that collects information on occupation, as well as information and sector[1]. It is with the LFS that recent works such as that of the Ministry of Science (2022) have tried to dimension the amount of the labor force classified as Human Resources in Science and Technology (HRST) in its report 'Women and Science', which considers as such technical, professional, scientific and intellectual personnel (group 2 of the CNO11), technical and professional support personnel (group 3), and adds to this people with higher level training (professional or university). This approximation is marked by the fact that the LFS does not offer public microdata with disaggregation of occupation below the first level of CNO11, and is based on OECD (1995), as is the data collected by the European Institute for Gender Equality (EIGE), which in fact broadens the criteria even further. The problem with this approximation is that the loss of resolution is excessive: it does not correspond exactly to people employed in science, technology and engineering: other subjects and areas of knowledge will be included in the training and occupation groups detailed.

The White Paper on Women in Technology published by the Ministry of Economy in 2021 first offers a sectoral view based on the INE's High Technology Indicators, listing the volume and proportion of women employed in different sectors with a scientific-technological load. The problem with the sectoral approach is that it does not distinguish whether a person employed in a sector performs scientific-technological tasks or not. Moreover, by logic, if we consider sector as defining a STEM occupation, we will not be able to answer the question of women's penetration in the STEM sector. Notwithstanding, the authors move on to a more detailed perspective that, in fact, picks up on the work previously done by González Ramos et al. (2017), which adds an additional layer of detail to the CNO11 over what has been seen so far: they consider as employed in the technology sector (a criterion perhaps slightly narrower in nature than the entire STEM field) those persons belonging to three CNO11 groups at two-digit disaggregation:

- Code 27: *software* and multimedia analysts and designers and database and network specialists.

- Code 31: science and engineering technical positions.

- Code 38: information and communications technology technical personnel, including information technology operations and user support, computer programmers.

Here we start from this refined classification to add two codes (24, 32) that we believe include occupations with intensive scientific-mathematical (code 24) and technological (code 32) content. A disaggregation of more than two digits will allow us to discard or include more finely, approaching the O*NET model, but we would incur in an excessive loss of sample (or in the de-anonymization of respondents to the surveys used).

The CNO11 is the reference classification in some sources besides the LFS; such as the Wage Structure Survey (EES) or the University Graduates Labor Market Insertion Survey (EILTU), but other sources use ISCO. Among them is one that allows us to answer all the questions listed at the beginning of this section (with the exception of those related to transitions from training to employment, for which we can use the EILTU) with publicly available microdata and a considerable level of reliability on the quality of the base samples: the Living Conditions Survey (LCS). The LCS offers in its microdata a two-digit disaggregation of ISCO. Building on Diego (2020) and expanding on Pérez Rupérez et al. (2018), we choose four ISCO groups as associated with STEM: science and engineering professionals, information, and communications technology (ICT) professionals, mid-level science and engineering professionals, information, and communications technology technicians.

This decision corresponds to an exhaustive analysis of the third and fourth level of depth subgroups that confirm these four segments. We left out others that we consider to be composed of a higher proportion of occupations with low or no STEM content, such as mid-level professionals in financial operations, clerks, accounting and record-keeping clerks, administrative support staff, people who deal directly with the public. This gives us some assurance that our definition is bounded for the Spanish economy as a whole, and does so with a reasonably restrictive criterion.

Classification of STEM occupations

This classification coincides in approximation and logic with the one used by the OECD when defining the occupations within the answers given by students who respond to PISA'22 at the age of 15 regarding their potential profession at the age of 30. However, it should be clarified that the coincidence is not exact because while the LCS only allows disaggregation at the second level of ISCO-08, PISA'22 goes down to four levels: in the LCS we only reach categories such as "Information and communications technology professional", while in PISA'22 they go down to distinguish between "system administrators" and "software developers", which allows a more refined selection.

	International Universal Classification of Occupations (CIUO) 2008	2011 National Classification of Occupations (CNO11)
STEM Professional	21 Science and engineering professionals	24 Professionals in the physical, chemical, mathematical and engineering sciences: Physicists, chemists, mathematicians and related professionals; Professionals in the natural sciences (biologists, agronomists, foresters, agricultural technicians, etc.); Engineers; Architects, urban planners and geographic engineers; Technical engineers; Technical architects, topographers and designers.
	25 Information and communications technology (ICT) professionals	27 Information technology professionals: software and multimedia analysts and designers; database and networking specialists
STEM Technician	31 Mid-grade science and engineering professionals	31 Science and engineering technicians: draughtsmen and technical draftsmen; physical, chemical, environmental and engineering science technicians; process control technicians (technicians in energy production facilities, waste and water treatment facilities, oil and natural gas refinery technicians, etc.); natural science technicians and related auxiliary professionals; maritime and aeronautical navigation professionals; physical, chemical and engineering science quality control technicians.
		32 Mining, manufacturing and construction engineering supervisors
	35 Information and Communications Technology Technicians	38 Information and communications technology (ICT) technicians: Information technology operations and user support technicians; Computer programmers; Audiovisual recording, broadcasting and telecommunications technicians

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