

GENDER DISPARITIES IN STEM DEGREES: EVIDENCE FROM HIGHER EDUCATION AND LABOR MARKET

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Abstract

The growing demand for highly qualified professionals in science, technology, engineering, and mathematics (STEM) has intensified concerns about persistent gender inequalities along educational and professional pathways. Despite sustained policy efforts, significant gender gaps remain in STEM education, particularly in engineering and information and communication technologies (ICT), with direct implications for labour market outcomes and wage structures in the technology sector. Understanding the drivers of these disparities is essential for designing effective interventions. This study examines gender inequality across the STEM pipeline, linking higher education choices to labour market outcomes, with a specific focus on ICT-related fields. First, a descriptive analysis is conducted using secondary data to assess gender gaps in STEM degrees at the European level, with particular attention to Spain and the Universitat Politècnica de València (UPV). Results confirm a pronounced under-representation of women in STEM programmes, especially in ICT degrees, which cannot be explained by differences in academic performance. Second, to investigate the determinants of students' engagement with STEM studies, an original questionnaire was developed based on an extensive literature review. The survey captures key individual, social, and institutional factors, such as interest, self-efficacy, aspirations, stereotypes, parental support, and teacher encouragement, that may influence STEM educational decisions. The final sample consists of 151 undergraduate students from the Universitat Politècnica de València. Data are analysed using structural equation modelling techniques PLS-SEM, drawing on validated theoretical frameworks. The findings indicate that gender disparities in STEM education translate into unequal participation in the technology labour market, where women occupy approximately 28% of STEM-related jobs in Spain, and less than 20% of ICT positions. While a gradual reduction in the gender pay gap is observed, occupational segregation remains substantial. The multi-group analysis reveals notable gender-specific effects: parental and teacher support play a more decisive role for women in shaping STEM career aspirations, whereas beliefs about the STEM sector exert a stronger influence on women's interest levels compared to men. Contrary to expectations, some hypotheses, such as the direct impact of gender stereotypes on aspirations, are not significant. Overall, the results highlight the importance of early social support mechanisms and institutional interventions in addressing gender inequality in STEM education and ICT careers, contributing to evidence-based policy discussions aligned with SDG 4 and SDG 5.

Keywords: *STEM career, gender inequality, wage gap, higher education, structural equation modeling.*

1. Introduction

The rapid digital transformation of modern economies has significantly increased the demand for highly qualified professionals in science, technology, engineering, and mathematics (STEM). These disciplines are widely recognised as key drivers of innovation, productivity, and economic competitiveness (European Commission, 2025). However, despite the growing importance of STEM skills, persistent gender disparities remain along the educational and professional pathways associated with these fields. Women continue to be underrepresented in many STEM disciplines, particularly in engineering and information and communication technologies (ICT), which limits both individual career opportunities and the diversity of talent available to the labour market.

At the European level, women represent nearly half of tertiary education graduates but remain significantly underrepresented in STEM programmes. According to European Comision, women account for approximately 32% of STEM graduates in the European Union, with even lower participation rates in ICT fields. The gender imbalance is particularly pronounced in engineering and computer science programmes, where women often represent less than one quarter of enrolled students. These disparities extend beyond higher education and are reflected in labour market outcomes. In Spain, women represent only 17.5% of the employed population with STEM education, highlighting the persistent underrepresentation of women in these areas (ONTSI, 2025). Such imbalances have important implications for innovation capacity, economic growth, and the achievement of gender equality goals.

The persistence of gender gaps in STEM has generated extensive research aimed at identifying the factors that influence students' educational choices and career aspirations. Previous studies have shown that these disparities cannot be fully explained by differences in academic performance or cognitive ability (Ceci et al., 2014; Wang and Degol, 2017). Instead, a complex combination of psychological, social, and contextual factors appears to shape students' engagement with STEM disciplines. These factors include individual interests, perceptions of competence, social expectations, exposure to role models, and support from family and educational environments (Cheryan et al., 2017).

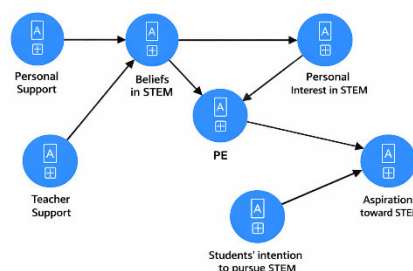
A widely used framework to explain career development processes is Social Cognitive Career Theory (SCCT) (Lent et al., 1994, Lent and Brown, 1996). SCCT posits that individuals' career interests, goals, and choices are shaped by the interaction of self-efficacy beliefs, outcome expectations, and personal goals within specific environmental contexts. Within the context of STEM education, students' confidence in their ability to successfully perform STEM tasks and their beliefs about the value and usefulness of STEM careers are key determinants of their interest and intention to pursue these fields. Furthermore, contextual influences such as parental encouragement, teacher support, and exposure to STEM activities can reinforce or weaken these beliefs. In addition to cognitive and motivational factors, gender stereotypes and social expectations may influence how students perceive STEM disciplines and their own capabilities within them. Stereotypical beliefs that associate technical competence or mathematical ability with men may discourage female students from considering STEM careers, particularly in male-dominated domains such as engineering and computer science (Cheryan et al., 2017). Within this context, understanding the determinants that shape students' interest and aspirations toward STEM careers is essential for designing effective educational and policy interventions aimed at reducing gender inequalities.

2. Conceptual analysis

2.1. Conceptual model

Based on SCCT (Lent et al., 1994, Lent and Brown, 1996), this study proposes a conceptual model to explain students' academic aspirations toward STEM degrees show in Figure 1.

Figure 1. Conceptual model of factors influencing students' STEM academic aspirations.



2.2. Research hypothesis

Based on Social Cognitive Career Theory (SCCT) and the literature review, the following hypotheses are proposed:

H1. Parental support positively influences students' beliefs about the value and importance of STEM studies.

H2. Teachers' support positively influences students' beliefs about the value and importance of STEM studies.

H3a. Students' beliefs about STEM positively influence their intention to pursue STEM studies.

H3b. Students' beliefs about STEM positively influence their perceived self-efficacy in STEM-related subjects.

H4. Students' intention to pursue STEM studies positively influences their perceived self-efficacy in STEM-related subjects.

H5. Gender stereotypes related to the STEM sector influence students' academic aspirations toward STEM degrees.

H6. Students' perceived self-efficacy in STEM-related subjects positively influences their academic aspirations toward STEM degrees.

3. Research method

3.1. Statistical analysis

This study followed a two-step analytical approach using Partial Least Squares Structural Equation Modelling (PLS-SEM). In the first stage, the measurement model was assessed to examine the relationships between latent constructs and their observed indicators, as well as to evaluate the reliability and validity of the measurement scales. Following the guidelines proposed by Hair et al. (2019), indicator reliability was assessed by analysing the outer loadings of the indicators, which should ideally exceed the recommended threshold of 0.70. Internal consistency reliability was evaluated using Cronbach's alpha (α) and Composite Reliability (CR), with acceptable values above 0.70. Convergent validity was assessed through the Average Variance Extracted (AVE), which should be greater than 0.50 (Fornell and Larcker, 1981). In addition, discriminant validity was examined using three complementary approaches: the Fornell–Larcker criterion, the analysis of cross-loadings, and the heterotrait–monotrait ratio (HTMT) of correlations, which should remain below the recommended threshold values of 0.85 or 0.90 (Henseler et al., 2015).

In the second stage, the structural model was evaluated in order to analyse the hypothesised relationships among the constructs. The significance and relevance of the structural relationships were assessed through bootstrapping procedures.

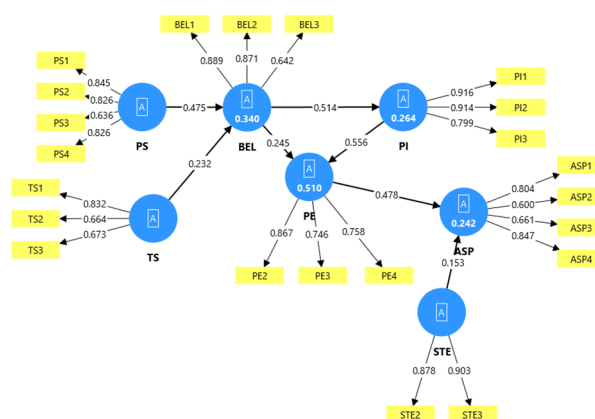
Finally, a multi-group analysis (MGA) was conducted to examine potential gender differences in structural relationships meanwhile the measurement invariance across gender was assessed using the MICOM procedure.

4. Results

4.1. Measurement model

4.1.1. Reliability and convergent validity. The measurement model was evaluated following the guidelines for Partial Least Squares Structural Equation Modelling (PLS-SEM) proposed by Hair et al. (2019). Since all constructs were specified as reflective composites (Type A), the assessment focused on examining the outer loadings of the indicators (Figure 2).

Figure 2. Outers loadings.



Indicator reliability was evaluated through the outer loadings, which should ideally exceed the recommended threshold of 0.70. Internal consistency reliability was assessed using Cronbach's alpha (α) and Composite Reliability (CR), with acceptable values above 0.70. Convergent validity was assessed through the Average Variance Extracted (AVE). Values greater than 0.50 indicate that the construct explains more than half of the variance of its indicators (Fornell and Larcker, 1981). The results confirm that all constructs meet these recommended thresholds.

4.1.2. Discriminant Validity. Discriminant validity was examined using two complementary approaches. First, the Fornell–Larcker criterion was applied by comparing the square root of the AVE of each construct with the correlations between constructs. In our case, the diagonal elements are greater than the correlations with other constructs, indicating adequate discriminant validity. Second, the heterotrait–monotrait ratio (HTMT) was analysed. All constructs obtain values of HTMT values below 0.90 indicate that constructs are empirically distinct (Henseler et al., 2015).

4.1.3. Significance of Indicator Loadings. The significance of the outer loadings was assessed using a bootstrapping procedure with 5,000 subsamples. Bootstrapping provides t-values and p-values to test the statistical significance of the loadings. The results indicate that all indicators are statistically significant ($p < 0.05$), confirming their contribution to the measurement of their respective constructs.

4.2. Structural model

The structural model was assessed following the procedures recommended by Hair et al. (2019). All hypothesis were supported (p -value < 0.05).

The explanatory power of the model was assessed through the coefficient of determination (R^2). According to Hair et al. (2019), values of 0.25, 0.50, and 0.75 can be interpreted as weak, moderate, and substantial explanatory power, respectively. In addition, the effect size (f^2) was examined to determine the contribution of each exogenous construct to the endogenous constructs. Values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

4.3. Multigroup analysis

A multi-group analysis (MGA) was conducted to examine potential gender differences in the structural relationships. Measurement invariance across gender was assessed using the MICOM procedure. The results of Compositional Invariance indicate that most constructs meet the invariance criteria, as the original correlations exceed the 5% quantile and permutation p-values are above 0.05. However, parental support (PS) does not achieve compositional invariance ($p = 0.001$), suggesting that the way this construct is formed differs between male and female students. Despite this exception, partial measurement invariance is established, which allows for meaningful multi-group comparisons of the structural relationships. The results indicate that most structural paths are statistically equivalent across male and female students. However, a significant difference emerges in the relationship between beliefs about STEM and the intention to pursue STEM studies.

5. Discussion

This study identifies beliefs about the STEM sector, parental support, and teachers' support as key factors shaping students' perceptions and motivations toward STEM careers. The results of the PLS-SEM model indicate that both parental and teachers' support significantly influence students' beliefs about STEM, highlighting the important role played by the social environment in shaping students' perceptions of STEM fields. These beliefs, in turn, strongly influence students' intention to pursue STEM studies, which subsequently contributes to the development of perceived self-efficacy in STEM-related subjects.

The results also show that perceived self-efficacy is the strongest predictor of academic aspirations in STEM, confirming the central role of confidence in one's own abilities when considering STEM educational pathways. In addition, gender stereotypes show a smaller but statistically significant effect on STEM aspirations, suggesting that although stereotypes may still influence students' perceptions, their impact is weaker compared with psychological factors such as beliefs, intentions, and self-efficacy.

From a theoretical perspective, these findings are consistent with Social Cognitive Career Theory (SCCT), which emphasizes the role of social context and cognitive factors in shaping career aspirations. The present study reinforces these findings by showing that support from parents and teachers contributes to strengthening positive beliefs about STEM, which in turn foster students' motivation and confidence in these fields.

From a practical perspective, these results suggest that initiatives aimed at strengthening students' beliefs and self-efficacy in STEM, together with increased support from parents and teachers, may contribute to fostering greater academic aspirations toward STEM careers.

Despite these contributions, the study presents several limitations. The sample is limited to university students, which may restrict the generalizability of the results. Future research could extend this model to secondary school students or early educational stages, where career aspirations are often formed, and could incorporate additional variables such as role models, institutional support, or exposure to STEM activities. Overall, the proposed model highlights the importance of beliefs, intentions, and perceived self-efficacy as central mechanisms explaining students' academic aspirations toward STEM careers, while also emphasizing the indirect but relevant role played by social support and gender stereotypes in shaping these aspirations.

Acknowledgements

This paper was financially supported by the Project of the Universitat Politècnica de València (PAID-06-23), “Support through Data Science, Social Media and Innovation to Enhance Digital Divide and Sustainability with a Gender Approach: An International Study (DIVIDDataSci)”.

References

- Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological science in the public interest*, 15(3), 75-141. <https://doi.org/10.1177/1529100614541236>
- Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others?. *Psychological bulletin*, 143(1), 1. <https://doi.org/10.1037/bul0000052>
- European Commission: Directorate-General for Research and Innovation. (2025). *Framework for the integration and evaluation of inclusive gender analysis in research and innovation content*, Publications Office of the European Union. <https://data.europa.eu/doi/10.2777/2434498>
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50. <https://doi.org/10.2307/3151312>
- Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2-24. <https://doi.org/10.1108/EBR-11-2018-0203>
- Henseler, J., Ringle, C., & Sarstedt, M. (2015). A New Criterion for Assessing Discriminant Validity in Variance-based Structural Equation Modeling. *Journal of Academic Marketing Science*, 43, 115-135. DOI 10.1007/s11747-014-0403-8.
- Lent, R. W., & Brown, S. D. (1996). Social cognitive approach to career development: An overview. *The Career Development Quarterly* 44, 310-321.
- Lent, R. W., Brown, S. D. & Hackett, G. (1994). Toward a unifying social cognitive theory career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45, 79–124.
- Observatorio Nacional de Tecnología y Sociedad (ONTSI). (2025). *Brecha digital de género. Edición 2025: Datos 2024*. Red.es – Ministerio para la Transformación Digital y de la Función Pública.
- Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational psychology review*, 29(1), 119-140. <https://doi.org/10.1007/s10648-015-9355-x>