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STEM degree trajectories among students in Catalonia: initial performance, gender and social origin

Trayectorias de los estudiantes en carreras científico-técnicas en Cataluña: rendimiento inicial, género y origen social

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ABSTRACT

This article explores the trajectories of STEM (Science, Technology, Engineering and Mathematics) degree students in Catalonia (Spain), focusing on the influence of initial academic performance in interaction with the sociodemographic factors of gender and parental educational level (PEL). By analysing a longitudinal database of 7 academic years (2012-2019) on newly enrolled STEM students in the Catalan face-to-face higher education system (11 universities; n= 10,274), it is examined how these factors influence the ability of students to persist and succeed in this academically difficult environment. A Group-Based Trajectory Model (GBTM) is used to rank student trajectories based on their annual rate of achievement. The predicted probability of belonging to each group is then calculated from several binary logistic regression models that introduce interactions between the various factors and, finally, first and second differences are calculated to estimate the influence

of these factors on group membership. The results indicate that first-year performance is a strong predictor of trajectory, with PEL and gender acting as moderators. Specifically, students from families with a university education and women tend to have better trajectories and greater persistence, even when they face first-year poor performance. The research contributes to understanding the factors that affect persistence and dropout in STEM degrees, highlighting the importance of considering the trajectory as a whole, and social and gender inequalities.

Keywords: educational equity, Higher Education, women's education, first generation college students, STEM education, students' trajectories, student sociology

RESUMEN

Este artículo explora las trayectorias de los estudiantes universitarios en carreras STEM (Ciencia, Tecnología, Ingeniería y Matemáticas) en Cataluña (España), centrándose en la influencia del rendimiento académico inicial en interacción con factores sociodemográficos, como el género y el origen social. Mediante el análisis de una base de datos longitudinal de 7 años académicos (2012-2019) sobre estudiantes de nuevo acceso a carreras STEM en el sistema universitario presencial catalán (11 universidades; n= 10274), se examina cómo estos factores influyen en la capacidad de estos estudiantes para persistir y tener éxito en un ambiente académicamente difícil. El análisis utiliza un Group-Based Trajectory Modelling (GBTM) para clasificar trayectorias de estudiantes en base a su tasa de rendimiento anual. Posteriormente se calcula la probabilidad predicha de pertenecer a cada grupo a partir de varios modelos de regresión logística binaria que introducen interacciones entre los diversos factores y, finalmente, se calculan las primeras y segundas diferencias para estimar la influencia de dichos factores sobre la pertenencia a cada grupo. Los resultados indican que el rendimiento inicial es un fuerte predictor de la trayectoria, con el origen social y el género actuando como moderadores. En concreto, los estudiantes de familias con nivel educativo universitario y las mujeres tienden a mostrar mejores trayectorias y más persistencia, incluso cuando se enfrentan a un mal resultado inicial. La investigación contribuye a comprender los factores que afectan la persistencia y el abandono en las carreras STEM, destacando la importancia de considerar la trayectoria en su conjunto, y tomando en cuenta las desigualdades sociales y de género.

Palabras clave: equidad educativa, Educación Superior, mujeres estudiantes, primera generación de estudiantes en la universidad, carreras científico-técnicas, trayectorias estudiantiles, sociología del estudiante

INTRODUCTION

Over the past two decades, the principles of equity and the social dimension of higher education have increasingly been incorporated into the formulation of

European university policies (Rome Ministerial Communiqué, 2020). Among the most salient aspects of these policies is the recognition of the growing diversity of students accessing higher education. This diversity is shaped, firstly, by the fact that many students face initial disadvantages stemming from their social background, gender, ethnicity, or other factors of inequality (Ariño Villarroya, 2014). Secondly, it reflects the varied interests and objectives that guide students' decisions and actions, which do not always align with the priorities of the university institution.

In this scenario, simple performance indicators based on criteria of institutional efficiency such as graduation rates are no longer sufficient, but rather students' entire trajectories must be considered (Tinto, 2017; Troiano et al., 2024). Factors to consider include how the student progresses through university, whether they are able to overcome the challenges encountered in contexts of varying difficulty, and whether they remain on the degree originally chosen or they modify their path. While these aspects are obviously linked to performance and final achievement or graduation, they are not exactly the same, such that identical trajectories can lead to divergent final results, or very different trajectories can have an identical final result (Haas & Hadjar, 2019; Pfeffer & Goldrick-Rab, 2011).

Within this framework, it is essential to examine trajectories beyond the evident influence of academic achievement, considering the potential inequalities arising from how students face this achievement according to their social origin or gender. Furthermore, this study focuses on a particularly challenging context, that of STEM (Science, Technology, Engineering and Mathematics) careers.

Trajectories and transitions

A trajectory at university can be defined as a succession of events relating to a student, and is basically made up of situations they encounter and the decisions they make. Decisions are influenced by what has happened previously (that is, they are path-dependent) and by students' expectations and objectives as they go through the academic years. In this regard, the trajectory has many shared aspects with the transitions between educational stages, except that it is a much more continuous process.

When studying transitions, one of the most consistent findings is the importance of social background and gender in explaining the inclination to go on to later stages in the education system, beyond the academic performance obtained. To this effect, students whose parents have a high educational level and women have a clear propensity towards continuing in education, choosing to move on to later educational stages, especially through the academic route, including university (Bernardi & Triventi, 2020; Gil-Hernández, 2019; Organisation for Economic Co-operation and Development [OECD], 2020; Sánchez-Gelabert et al., 2024; Valdés, 2020).

Likewise, in the case of academic trajectories within the university, performance is the primary factor that determines what happens, which decisions are made, and what final outcomes are achieved. However, social attributes once again play a relevant role. In this regard, it is known that the children of parents with university degrees are more persistent, that is, they tend to remain within the university system (de la Cruz-Campos et al., 2023; Lorenzo-Quiles et al., 2023), even where there is a previous poor performance, using strategies or resources such as, for instance, changing their field of study (Sánchez-Gelabert & Troiano, 2023), just as it is known that women have a greater tendency to complete their degrees (The United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2021).

Trajectories and transitions in the STEM framework

The subjects taught in STEM degrees are usually highly academically challenging, which can be verified using subjective perception indicators and other more objective ones (González-Pérez et al., 2022; Sáinz, 2017). Furthermore, these degrees have a particular social composition, with more students who are men and with a high PEL, and a particularly striking male predominance in engineering.

Lower participation and a higher risk of dropping out are usually detected among students who are the first generation in their family to access university (Triventi, 2013). This trend is accentuated in the case of STEM degrees due to the increasing academic difficulty in this environment, and it being more difficult to overcome other barriers such as the perception of academic fit, the concept teachers have of these students and the impostor syndrome (Canning et al., 2020; Casanova et al., 2023; Dika & D'Amico, 2016; Ives & Castillo-Montoya, 2020).

This is also the case in Spain and Catalonia. Degree programmes that are more difficult to complete carry a risk that is significant enough for first-generation university students to avoid them (Ariño et al., 2022; Barañano Cid & Finkel Morgenstern, 2014; Secretaría General de Universidades, 2019; Troiano et al., 2017). Beyond access, there are apparently no specific studies on the persistence of first-generation students in STEM degrees in the Spanish or Catalan context, so this article aims to help fill this research gap.

In terms of gender, contrary to what happens in other areas of knowledge, women have minority access to STEM degrees (Mateos Sillero & Gómez Hernández, 2019; UNESCO, 2019), the distances increasing over time for the most technological subareas (Rodriguez & Lehman, 2017), but with a much smaller or non-existent gap for the life sciences subareas (Agència per a la Qualitat del Sistema Universitari de Catalunya, 2021; Usart et al., 2022).

Many studies have attempted to identify the factors that explain the distance between women and scientific and technical disciplines of this type. Among the

most prominent are the psycho-cognitive ones, such as the impostor syndrome and self-efficacy, the varying intensity of which is grounded in the experience the person has had with learning these subjects and their beliefs regarding whether they can be learned or if it is a question of natural talent (growth mindset). This is a particularly important factor in the case of mathematics, a subject that plays a leading role in many of the degrees in the STEM group (Kahn & Ginther, 2017; Malespina et al., 2023; Sebastián-Tirado et al., 2023).

Beliefs and interaction with significant others also intervene when it comes to assuming a gender role as one's own, together with attributing certain stereotyped values to science. In this regard, when the female role tends to be associated with community values, and the characteristics of science are associated with individualism and competitiveness, the lack of fit, interest and motivation become evident (Erdmann et al., 2023; González-Pérez et al., 2022; Petroff et al., 2022; Sebastián-Tirado et al., 2023).

Last, and also linked to socially attributed gender roles, the expectation of high professional demand in a highly competitive environment fits with the role of breadwinner focused on professional success assigned to men, while posing difficulties for commitment to family and child-bearing socially attributed almost exclusively to women (Petroff et al., 2022). Notably, all these aspects appear to soften when parents are highly educated, helping students to choose degrees that are not congruent with gender roles (González-Pérez et al., 2022).

International research indicates that there is a lower persistence of women in STEM degrees (Erdmann et al., 2023; Fisher et al., 2022; Kaganovich et al., 2023; Ma & Xiao, 2021). Remarkably, studies carried out in Spain and Catalonia point to the opposite trend, i.e. few women access STEM degrees, but they graduate more often than men in all branches of STEM except computer science (Mateos Sillero & Gómez Hernández, 2019; Usart et al., 2022). Having said that, although the dropout rate among women is lower in the Spanish context, when it does occur studies point to the same factors identified in other countries in conjunction with those examined previously to explain lower initial enrolment of women in STEM areas.

Self-efficacy thereby reappears, which is maintained or eroded depending on the context encountered when at university (Kahn & Ginther, 2017; Sebastián-Tirado et al., 2023), as well as beliefs about gender roles, affecting the ability to identify with the discipline, the sense of belonging and the feeling of isolation in a hostile climate, for example, when boys avoid interacting with their female colleagues or including them in work groups (Fisher et al., 2022; Hardtke et al., 2023; Rodriguez & Lehman, 2017; Sáinz, 2017; Sax et al., 2018). To these already known elements must be added the threat of stereotype (Pennington et al., 2016) that acts in varying degrees of intensity in contexts with micro-discrimination, generating stress, isolation and worsening of cognitive abilities (Fietta et al., 2023; González-Pérez et al., 2022; Ma & Xiao, 2021; Ong et al., 2018).

Standing out among the possible factors that could explain the greater persistence of women, and which has also been identified in some international studies evaluating interventions to improve women's retention (Erdmann et al., 2023; Vooren et al., 2022), is their high motivation to obtain a good education as a way to combat the structural difficulties of female discrimination in the labour market (Ariño et al., 2022; González-Pérez et al., 2022; Ma & Xiao, 2021; Petroff et al., 2022; Sánchez-Gelabert et al., 2024). From there, the factors that favour the persistence of women in STEM degrees depend on certain conditions, including having the support of family and friends (González-Pérez et al., 2022; Hardtke et al., 2023), whether the institution is welcoming enough to combat the stereotype of the discipline by means of policies of support, guidance and the promotion of interaction (Kahn & Ginther, 2017; Ong et al., 2018; Petroff et al., 2022), whether they have had effective prior guidance (Erdmann et al., 2023), and if they have a high perception of control capacity and self-efficacy (González-Pérez et al., 2022; Pennington et al., 2016).

In this context, the primary objective of this study is to examine how, given an initial level of academic performance (first-year performance), social background and gender influence the trajectory that the student will eventually develop. Particular attention will be given to exploring the case of students with poor initial performance who manage to overcome this adverse situation. A series of specific objectives are proposed:

1. To establish a typology of trajectories and describe it in terms of initial performance, final status, family educational background, and the gender of students predominant in each type;
2. To analyse the relationship between initial performance and trajectory type;
3. To examine the moderating effect of parental educational level on the relationship between initial performance and trajectory type;
4. To analyse the moderating effect of gender on the relationship between initial performance and trajectory type.

METHODOLOGY

Sample description

The sample is composed of a cohort of students who, in the 2012-2013 academic year, entered for the first time a degree offered by the 12 universities of the Catalan university system (n=44285). This system includes seven public universities (n=32663), four private universities (n=4246) and one distance university (n=7376). For the purposes of this article, the analysis focuses specifically on students enrolled in face-to-face universities in degrees belonging to the branches of Engineering and Architecture, and Science, commonly known as STEM degrees (n=10274).

In some of the variables analysed, the sample is reduced due to the lack of response to certain questions in the survey or due to the absence of data in the registry.

Table 1

Descriptive statistics of the study sample: new entrants to STEM degrees at onsite universities in the Catalan university System in 2012-2013

Parental Educational Level (PEL)	**n**	**%**
Non-University	4845	51.28
University	4603	48.72
Total	*9448*	*100*

Gender	**n**	**%**
Woman	3054	29.73
Man	7220	70.27
Total	*10274*	*100*

Field of study	**n**	**%**
Sciences	2730	26.57
Engineering/Architecture	7544	73.43
Total	*10274*	*100*

Age	**n**	**%**
Up to 25	9741	94.81
26-35	411	4
Over 35	122	1.19
Total	*10274*	*100*

Access route	**n**	**%**
Academic track	7613	74.1
Vocational track	1217	11.85
Other	1444	14.05
Total	*10274*	*100*

Admission grade				
Mean	s.d.	N	Min	Max
8.83	2.10	9611	5.00	14.00

Initial Performance Rate (IPR)				
Mean	s.d.	N	Min	Max
67.12	34.09	10274	0	100

Instruments and Variables

The longitudinal database on which the analyses were carried out has been built from the combination of registration and survey data, all of which are collected by the Department of Research and Universities of the Government of Catalonia.

The survey includes students' sociodemographic and educational information. The registration data are administrative data on first-year enrolment of a cohort of new students. To these data are added academic registration data for the following 6 years up to the 2019-2020 academic year.

The variables used in the analysis are as follows:

Dependent variable: Trajectories. This variable is derived from the construction of a typology based on the annual performance rate.

Independent variables: Initial performance rate (IPR), parental educational level (PEL), and gender.

Control variables: Field of study, admission grade, age, and access route.

Procedure

The analytical strategy is structured into two phases. In the first phase, corresponding to specific Objective 1, a typology of trajectories is constructed using the variable *annual rate of academic performance*, calculated by dividing the number of credits earned by the number of credits enrolled each year and multiplying the result by 100. Students who did not enrol in any credits in subsequent academic years and who did not graduate are assigned a rate of 0 for those years, indicating that they did not earn any credits during that period. Conversely, students who have already graduated are considered as missing from the year following their graduation, as they have completed all required credits, rendering the calculation of their performance rate irrelevant.

Once the trajectory groups have been established, they are descriptively characterized in relation to the independent variables (initial performance rate, parental educational level, and gender), as well as the final academic status of the students in each group.

In the second phase of the analysis, the dependent variable is redefined as the trajectory group to which each student has been assigned. First, the relationship between initial performance and trajectory is analysed, introducing parental educational level as a mediating variable in this relationship (Objectives 2 and 3). Subsequently, the analysis is repeated, incorporating gender as a mediating variable (Objectives 2 and 4).

Data Analysis

The typology of trajectories was developed using a Group-Based Trajectory Model (GBTM), proposed by Nagin (2005), with the TRAJ plugin for STATA (Jones & Nagin, 2013). This methodology groups similar trajectories based on repeated measurements

of the same variable. The procedure involves selecting an appropriate number of groups and determining, for each group, the polynomial order of the curve that represents each trajectory (Sánchez-Gelabert, 2022). Various models are tested for each group until the optimal model is identified, where all curves are statistically significant, no group represents less than 5% of the sample, and the Bayesian Information Criterion (BIC) no longer decreases when additional groups are included.

To estimate the probability of belonging to each of the trajectories identified by the GBTM (dependent variable: trajectory), two sets of binary logistic regressions were performed. In the first set, the independent variables included initial performance rate (IPR) and parental educational level (PEL), as well as their interaction. In the second set, the same procedure was followed, but gender was introduced as an independent variable interacting with IPR. In both analyses, the previously mentioned control variables were included.

The procedure recommended by Mize (2019) was followed for the estimation, interpretation, and presentation of nonlinear interaction effects. Predicted probabilities were calculated and plotted across the full initial performance distribution to determine the significance and magnitude of the effect. Subsequently, the first and second differences in the marginal effect of IPR, mediated by PEL or gender, were computed.

First differences involve measuring the marginal effect of IPR on the probability of belonging to a specific trajectory group, stratified by gender (male or female) or PEL (students with university-educated parents versus non-university-educated parents). The sign of the effect (and the slope of the line) indicates the growth relationship between the two variables; for instance, if the probability of belonging to a trajectory group decreases as performance increases, the marginal effect will have a negative sign.

On the other hand, second differences compare both marginal effects, providing a measure to determine whether the effect of IPR is more significant for one subgroup compared to the other.

RESULTS

University trajectories of a cohort of students doing STEM degrees

To address the first objective, the typology of trajectories followed by students is first presented, followed by a characterization of the resulting groups in terms of their initial performance rate (IPR), final status, and the predominant parental educational level (PEL) and gender in each group.

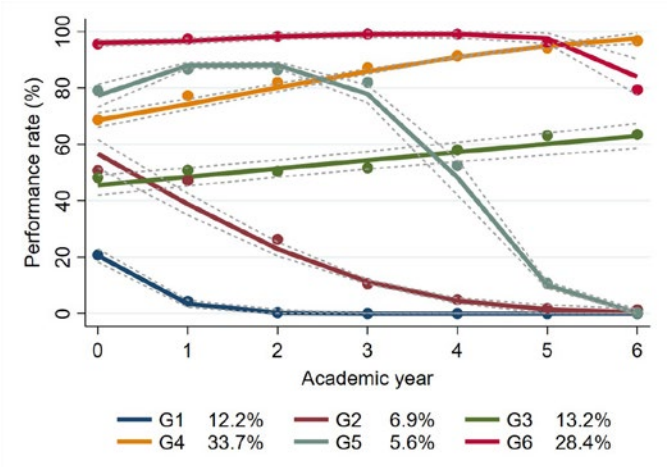
Using the GBTM, academic trajectory groups were estimated based on performance rates (number of credits passed divided by credits enrolled) for each year from 2012 to 2019. Table A1 of the annex contains the data of the successive

models tested, and Table A2 calculates the viability and quality indicators of the selected model.

Figure 1 is a representation of the evolution of the trajectory of the six groups that make up the final typology. The groups are ordered according to the average performance rate obtained by the students in the group at time 0 (IPR), which corresponds to the end of the first academic year (the exact average can be read in the last row of Table 2).

Figure 1

Group-based trajectory model



Note. Group labels: G1: Early dropout; G2: Slow dropout; G3: Intermediate; G4: Improvement; G5: Late dropout; G6: Optimal.

G1, which contained 12.2% of the sample, started the trajectory with very low performance (21% of credits achieved) and left the university system very quickly. Table 3 shows how the most likely final situation for these students is dropout (99%), with Table 2 evidencing a clear overrepresentation of first-generation students and men in this early dropout group.

G2, the slow dropout group containing 6.9% of the sample, started with half the number of credits passed, progressing with worsening performance until 90.5% of the group was in a situation of dropout at the end of our study period. An overrepresentation of male and first-generation students was again detected.

G3, which was labelled as *intermediate* and represented 13.2% of students, had worse initial performance (47.3% passed credits) compared to the previous group, but progressed in the opposite direction, remaining at an average level of

performance and with a majority managing to graduate (22.4%) or persist (71.7%). Once again, in this group there were more men with non-university PEL.

G4 was the largest group (33.7%). It was labelled as *improvement* because these students started the trajectory with just over two-thirds of credits passed, improving their performance over the years until almost 95% of them graduated, although mostly later than the expected time. Students with university PEL were somewhat more often included in this group, and there was almost no difference by gender.

G5, the late dropout group, made up of only 5.6% of students, was a mixture of somewhat diverse situations. Despite starting with a very good proportion of credits already achieved (77.9%) and generally staying at these levels, they ended up with very low performance rate and a large number of dropouts (60.9%). Very small differences were observed in terms of PEL and gender.

Last, G6 was the second largest group (28.4%), containing students who started with a very high average performance rate of 96.9% and continued in this vein, and were labelled *optimal*. Two-thirds of this group graduated on time and a further 30% later. Women clearly stand out in this group, and there is also an overrepresentation of university PEL.

Table 2

Percentage membership in each trajectory group according to Parental Educational Level (PEL) and gender, and the average of the initial performance rate (IPR)

	G1. Early dropout	G2. Slow dropout	G3. Intermediate	G4. Improvement	G5. Late dropout	G6. Optimal	n	Total %
PEL								
Non-University	14.98	7.7	13.21	32.57	4.71	26.83	*4845*	*100*
University	8.82	5.37	11.93	38.17	3.65	32.07	*4603*	*100*
Total	*11.98*	*6.56*	*12.58*	*35.3*	*4.19*	*29.38*	*9448*	*100*
Gender								
Woman	8.48	4.65	9.04	34.12	3.77	39.95	*3054*	*100*
Man	14.17	7.51	14.06	35.6	4.6	24.07	*7220*	*100*
Total	*12.48*	*6.66*	*12.57*	*35.16*	*4.35*	*28.79*	*10274*	*100*
IPR								*Media*
Mean	20.97	51.47	47.33	67.78	77.94	96.92		*67.12*
(s.d.)	(25.24)	(31.17)	(29.29)	(27.47)	(26.38)	(9.04)		*(34.09)*
n	*1282*	*684*	*1291*	*3612*	*447*	*2958*		*10274*

Table 3
Observed final status (7 years after admission) according to trajectory group. Percentages

	Graduated on time	Graduated with delay	Persistence	Dropout	*Total*	
					n	*%*
G1. Early dropout	0.31	0	0.86	98.83	*1282*	*100*
G2. Slow dropout	0.29	0	9.21	90.50	*684*	*100*
G3. Intermediate	0	22.39	71.73	5.89	*1291*	*100*
G4. Improvement	10.35	84.11	5.40	0.14	*3612*	*100*
G5. Late dropout	1.12	21.25	16.78	60.85	*447*	*100*
G6. Optimal	67.55	31.10	1.12	0.24	*2958*	*100*
Total	*23.19*	*42.26*	*12.68*	*21.86*	*10274*	*100*

In short, in this first part of the analysis, it is concluded that the optimal trajectory is much more followed by girls and the university PEL group, and obviously by those who perform better in the first year. It is also observed that the children of parents with a university degree are more capable of improving a not-so-good initial performance (G4 Improvement).

The relationship between initial performance and trajectory

In this second phase of the analysis, aligned with objectives 2, 3, and 4, the aim was to find out what influence PEL and gender have on the evident relationship between initial performance and the trajectory eventually followed by students. Ultimately, the goal is to determine whether these two sociodemographic variables play a moderating role in this relationship.

Firstly, the role of PEL is examined. Figure 2 shows the probabilities of belonging to each trajectory group according to initial performance and PEL (objectives 2 and 3). It can be observed that while the probability of belonging to G1 (early dropout) is closely related to the performance obtained in the first year (with a little compensation for low IPR in students with university PEL), this relationship is much weaker to explain belonging to the other two types of dropout groups, slow and late (G2 and G5, respectively).

IPR also clearly influences the probability of belonging to G6, characterised by optimal performance throughout the entire period, and with no differences by PEL. It also influences belonging to G3, the group that follows a trajectory that advanced slowly throughout the observed period, albeit weaklier.

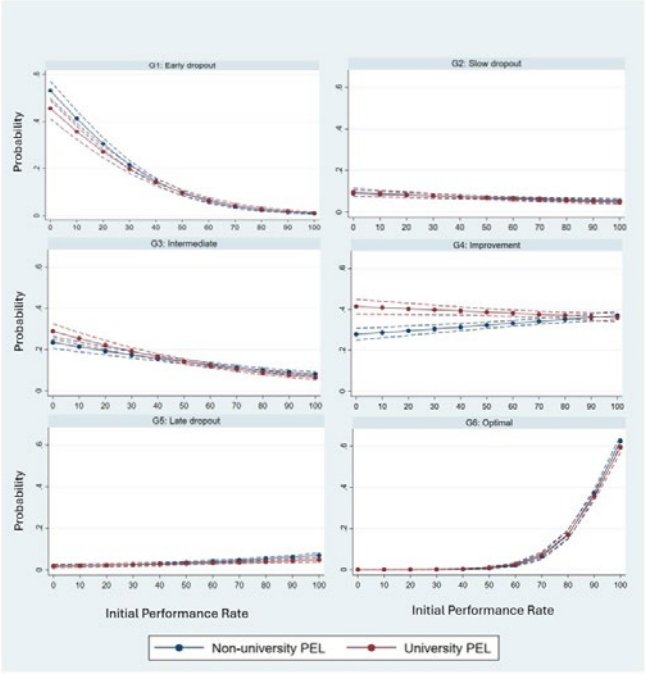
As can be observed in the graphs (Figure 2), when initial performance is poor (let's say from 0% to 40% of credits passed in the first year), the student is most likely to

belong to G1 (early dropout), G3 (slow progress) or G4 (greatly improving the initial situation). Among from these three options, small differences are observed in the trajectories that students follow according to their PEL.

In this regard, the early dropout of G1 at these performance levels is a little more likely to affect those with non-university PEL, while the reverse is that the slow progress of G3 is somewhat more likely among students with university PEL, and this trend is seen more clearly for the probability of following an improvement trajectory (G4), which is higher among those with university PEL. In fact, only for these three groups are the small second differences (Table 4) of the marginal effect of IPR statistically significant, at a p-value level of less than 0.01.

Figure 2

Effect of initial performance rate (IPR) and parental educational level (PEL) on the probability of belonging to each trajectory group. Predicted probabilities



Note. The predicted probabilities were calculated from a logistic regression for each trajectory group (belonging to Gx versus not belonging to Gx). In the model, the IPR and PEL, and the interaction between the two, were introduced as independent variables, in addition to the following vector of control variables: Gender, Admission grade, Access route, Age and Field of study. Confidence intervals at 95%.

Table 4 shows the marginal effect of IPR for each group (university PEL or non-university PEL), with positive, negative or zero results depending on the steepness

of the curve in the graphs in Figure 2. The effects are very small, with initial performance showing to have very little influence for some groups (the lines in the graph are almost flat and the marginal effects are close to zero). Only in the cases of the G1 and G6 does initial performance have a clear effect. The marginal effect of the IPR to explain belonging to G4 is close to zero along the entire initial performance distribution, although it is the group with the maximum distance between the two PELs. To this effect, this second very small difference is the only one that is significant at a level of $p < 0.001$.

Table 4

Marginal effect of initial performance rate (IPR) and parental educational level (PEL) on the probability of belonging to each trajectory group

	G1. Early dropout	G2. Slow dropout	G3. Intermediate	G4. Improvement	G5. Late dropout	G6. Optimal
Marginal effect of IPR						
Non-University PEL	-0.003 (0.000)***	-0.000 (0.000)***	-0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.012 (0.000)***
University PEL	-0.003 (0.000)***	-0.000 (0.000)***	-0.002 (0.000)***	-0.001 (0.000)*	0.000 (0.000)**	0.012 (0.000)***
Second difference						
	0.000 (0.000)**	-0.000 (0.000)	-0.001 (0.000)**	-0.001 (0.000)***	-0.000 (0.000)*	-0.000 (0.000)

*** p ≤ .001 | ** p ≤ .01 | * p ≤ .05.

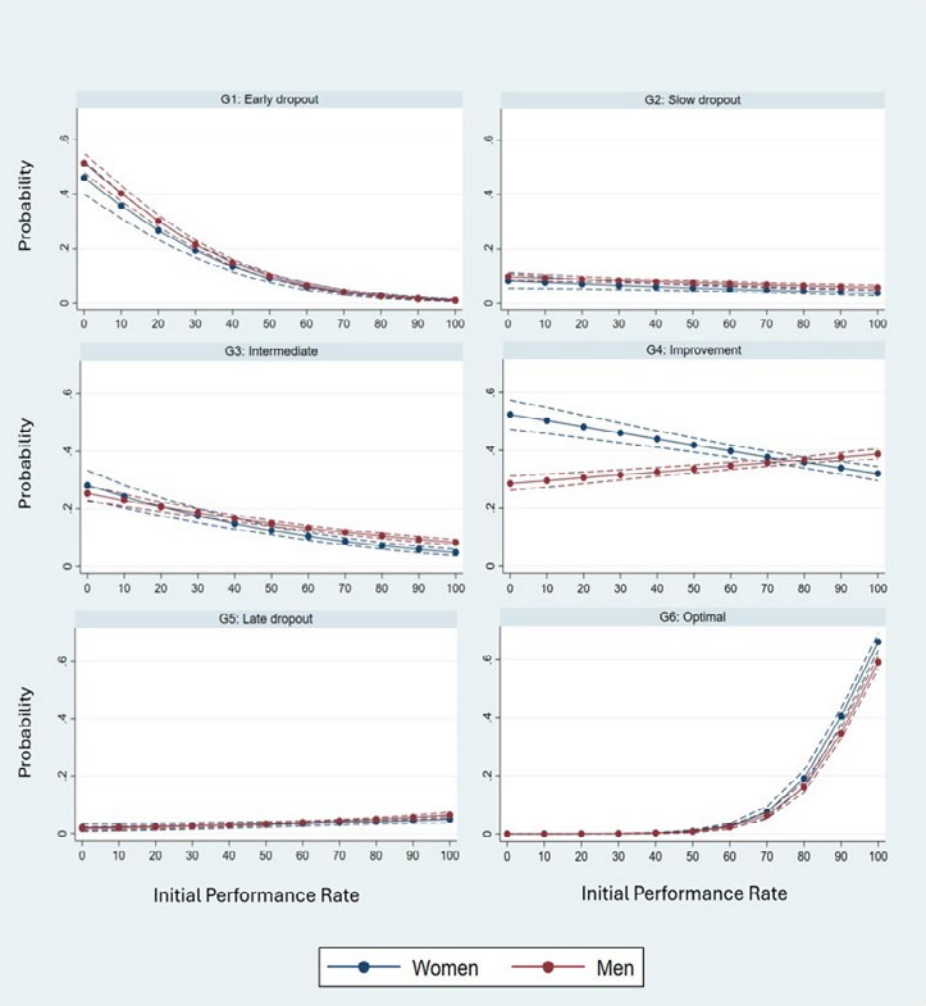
Next, the role of gender is examined as a possible moderating variable in the relationship between initial performance and the trajectory group to which a student belongs (objectives 2 and 4). Figure 3 shows these probabilities along the entire distribution of initial performance, for both men and women. Obviously, it is again the case that the influence of IPR (objective 2) is low in the groups of slow dropouts (G2) and late dropout (G5), while it is more important in explaining belonging to the other groups, especially early dropout (G1) and optimal performance (G6).

For the gender analysis, a greater interaction emerges in the improvement trajectory (G4). This means that girls manage to improve their trajectory more than boys, despite having started with some difficulty. Table 5 confirms that the most relevant differences are observed in G4, since this is the only second difference that is significant[1].

1 However, for both PEL and gender differences, the distance is so small that it does not allow the calculation of the decomposition of the direct effect and the mediated effect using the KHB method. The results show inconsistencies, giving negative values or losing statistical significance. The results can be seen in Table A3 and A4 of the annex.

Figure 3

Effect of initial performance rate (IPR) and gender on the probability of belonging to each trajectory group. Predicted probabilities



Note. The predicted probabilities are calculated from a logistic regression for each trajectory group (belonging to Gx *versus* not belonging to Gx). In the model, the IPR and the gender, and the interaction between the two, are introduced as independent variables, in addition to the following vector of control variables: Parental educational level, Admission grade, Access route, Age and Field of study. Confidence intervals at 95%.

Table 5
Marginal effect of initial performance rate (IPR) and gender on the probability of belonging to each trajectory group

	G1. Early dropout	G2. Slow dropout	G3. Intermediate	G4. Improvement	G5. Late dropout	G6. Optimal
Marginal effect of IPR						
Woman	-0.003 (0.000)***	-0.000 (0.000)**	-0.002 (0.000)***	-0.002 (0.000)***	0.000 (0.000)*	0.012 (0.000)***
Man	-0.003 (0.000)***	-0.000 (0.000)***	-0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.012 (0.000)***
Second difference						
	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.003 (0.000)***	0.000 (0.000)	-0.000 (0.000)

*** p ≤ .001 | ** p ≤ .01 | * p ≤ .05.

DISCUSSION AND CONCLUSIONS

In the present study, the trajectories of students enrolled in STEM degrees within the Catalan university system have been analysed over a seven-year period. The primary aim has been to examine the influence of parental educational level (PEL) and gender on the well-known relationship between initial performance (in the first year) and subsequent academic trajectory. The specific objectives were as follows: 1) to construct a typology of the trajectories followed by students and characterize them; 2) to examine the relationship between initial performance and the trajectory followed; 3) to analyse the effect of PEL on this relationship; and 4) to analyse the effect of gender on this relationship.

Regarding objective 1, the findings revealed that, in STEM degrees, only 28% of the student cohort follows the trajectory envisioned by the institution. If those who follow an improving trajectory—thus approaching the "ideal trajectory" planned by the institution—are included, this figure rises to 62%. Nonetheless, there remain numerous cases in which students pursue paths requiring intervention and support to prevent their trajectory from ending in permanent dropout. Notably among them is a minority but still important group made up of students who follow an apparently successful trajectory and end up dropping out. This is a group that gathers diverse situations and needs further study to clarify the reasons and dynamics underlying this change of direction in their trajectory.

Inequality based on social origin is reflected in the fact that the most complex trajectories that most often lead to dropout are more followed by first-generation

students. This trend works in the same direction as the one found at international level (Dika & D'Amico, 2016; Ives & Castillo-Montoya, 2020; Triventi, 2013). However, the original contribution of this article is the specific analysis of the relationship between initial performance and trajectory followed (objective 2), showing that students with university PEL are more often able to overcome poor initial performance (objective 3).

The greater ability to improve initial poor performance among the children of university PEL is another demonstration of compensatory advantage which, although originally used to explain transitions between educational stages (Bernardi & Cebolla, 2014), can be applied here to the continuous transitions we find in a trajectory within a certain educational stage (Tieben, 2020). From the available data, it is not possible to identify what mechanisms are put in place to produce this effect of compensatory advantage when faced with setbacks, but the results of other researchers point to various resources to this effect. Good examples of this are complementary private classes, the financial means to extend the period to obtain the degree, reorientation of the trajectory towards other degrees, or simply the lower persistence of first-generation students when their first set of results at university are poor (Casanova et al., 2023; de la Cruz-Campos et al., 2023; Dika & D'Amico, 2016; Herbaut, 2020; Lorenzo-Quiles et al., 2023; Sánchez-Gelabert & Troiano, 2023; Tieben, 2020).

Gender inequality follows a different pattern (objective 1). First of all, it should be borne in mind that women represent only 30% of the population that accessed the Catalan university system for the first time in 2012 to study STEM degrees, when they represent the majority in the rest of the fields of study. However, women clearly follow better trajectories more often. This result differs from those obtained in the international arena (Erdmann et al., 2023; Fisher et al., 2022; Kaganovich et al., 2023; Ma & Xiao, 2021), but confirms what another research has found in Spain (Mateos Sillero & Gómez Hernández, 2019; Usart et al., 2022).

The present study shows that even when they have initial difficulties, women follow recovery trajectories more often than men do (objective 4). As mentioned in the theoretical introduction to this article, some research finds factors in favour of greater female persistence, such as the greater motivation to obtain a qualification that helps them in a discriminatory labour market (Ariño et al., 2022; González-Pérez et al., 2022; Ma & Xiao, 2021; Petroff et al., 2022; Sánchez-Gelabert et al., 2024), and having specific positive circumstances such as a supportive social and institutional environment or a high perception of self-efficacy (Erdmann et al., 2023; González-Pérez et al., 2022; Hardtke et al., 2023; Kahn & Ginther, 2017; Ong et al., 2018; Pennington et al., 2016; Petroff et al., 2022). Unfortunately, the data available here do not allow for verifying the influence of any of these factors, which is an important limitation of the present work. While the analysis has accurate administrative data, it lacks longitudinal survey information.

Another important limitation of this study derives from not having differentiated STEM degrees in a more detailed way. Although an important step has been taken by distinguishing STEM degrees from the rest of university degrees, and by systematically introducing the field of study variable as a control (differentiating between science and engineering), the degrees grouped in these two branches are very diverse from each other. In order to carry out a more precise analysis by sub-branch, a larger population or pooled samples of several nearby graduating classes would be necessary.

Despite these limitations, this study provides valuable lessons for guiding educational policies and interventions. Firstly, the findings highlight the existence of distinct types of dropouts occurring at different stages, probably linked to different motivations and circumstances. In addition to deepening our understanding of these patterns, especially of the puzzling late dropout, it is clear that universities need to implement continuous monitoring systems. Such systems would enable the early identification of at-risk situations and facilitate swift responses.

Secondly, although women remain a minority in STEM fields, they have shown better academic trajectories compared to men, even demonstrating recovery from poor initial performance—contrary to trends observed in many other parts of the world. If, as other referenced studies suggest, this responsiveness stems from higher achievement orientation and motivation, implementing interventions aimed at all students would be advisable. These interventions could include more effective pre-enrolment guidance for study selection and fostering intrinsic motivation once students embark on their academic journey, for instance, by linking academic knowledge with future professional practice.

Finally, the study reveals that students with university-educated parents exhibit a greater ability to overcome initial academic challenges. Previous research suggests that this resilience is facilitated by resources such as tutoring services, financial support to extend their studies, or academic reorientation. These forms of support, often inaccessible to students from lower socioeconomic backgrounds, could be provided by universities through complementary academic support services, personalized academic guidance (including reorientation), and more tailored mentoring programs.

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ANNEX

Table A1
Model selection process

Number of groups	Polynomial function	Model BIC 1 N=58,978	Model BIC 2 N=10,274	Groups < 5%	All the curves significant
1	3	-168257	-168252		sí
2	33	-152765	-152757	0	sí
3	333	-149723	-149710	0	sí
4	3333	-148007	-147989	0	no
4	3233	-148070	-148053	0	no
4	3133	-148234	-148218	0	sí
5	31333	-147244	-147224	0	no
5	21333	-147137	-147117	0	no
5	21323	-147132	-147114	0	no
6	213233	-146832	-146809	1	no
6	212233	-146827	-146805	1	no
6	212223	-146598	-146577	0	no
6	112223	-146593	-146573	0	no
6	111223	-146589	-146570	0	sí
7	1112233	-146440	-146417	2	no

The penultimate solution simultaneously lowers the absolute BIC value and has no group below 5%, and all the curves are significant (Sánchez-Gelabert, 2022). The last solution does not lower the absolute BIC value. The adjustment indicators meet the recommended criteria. The penultimate model is therefore taken as the final solution.

Table A2
Fit indicators for the selected model

	G1	G2	G3	G4	G5	G6
APPA	0.95	0.9	0.89	0.84	0.91	0.88
OCC	131.36	120.77	50.77	10.45	163.81	17.81

Table A3

Decomposition of the influence of parental educational level (PEL) on belonging to G4 (Improvement) mediated by the variable initial performance rate (IPR)

Decomposition of PEL and IPR		
	Coefficient	**Standard Error**
PEL mediated by IPR	-0.001	0.001
PEL direct influence	0.160**	0.046
PEL total influence	0.159**	0.046

*** p ≤ .001 | ** p ≤ .01 | * p ≤ .05.
N=9016; Pseudo R2=0.02.

Table A4

Decomposition of the influence of gender on belonging to G4 (Improvement) mediated by the variable initial performance rate (IPR)

Decomposition of Gender and IPR		
	Coefficient	**Standard Error**
Gender mediated by IPR	-0.005	0.004
Gender direct influence	-0.072	0.051
Gender total influence	-0.077	0.051

Note: No value is significant.
N=9016; Pseudo R2=0.02.