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*Research article*

## The mediating role of mathematical literacy in first-year educational outcomes in Business Administration and Management degrees: A gender-based analysis

Inmaculada Galván-Sánchez<sup>1</sup>, Alexis J. López-Puig<sup>2</sup>, Margarita Fernández-Monroy<sup>1,\*</sup> and Sara M. González-Betancor<sup>3</sup>

<sup>1</sup> Departamento de Economía y Dirección de Empresas, Universidad de Las Palmas de Gran Canaria (ULPGC), Edificio de Economía, Empresa y Turismo (Campus de Tafira), 35017 Las Palmas de Gran Canaria, España

<sup>2</sup> Departamento de Matemáticas, Universidad de Las Palmas de Gran Canaria (ULPGC), Edificio de Informática y Matemáticas (Campus de Tafira), 35017 Las Palmas de Gran Canaria, España

<sup>3</sup> Departamento de Métodos Cuantitativos en Economía y Gestión, Universidad de Las Palmas de Gran Canaria (ULPGC), Edificio de Economía, Empresa y Turismo (Campus de Tafira), 35017 Las Palmas de Gran Canaria, España

\* **Correspondence:** Email: margarita.fernandez@ulpgc.es; Tel: +34928458143.

**Abstract:** In the field of higher education, the transition from secondary to tertiary education is crucial to reduce dropout rates and to improve the educational outcomes. This study aims to investigate various predictors that affect the academic performance of first-year Business Administration and Management (BAM) students, thereby emphasizing the importance of mathematical literacy. Using a structural equation modeling approach, this investigation looks beyond gender to include baccalaureate choices such as the mathematics pathway and the mathematics entrance exam grades. This study adopts a comprehensive approach by using administrative data from a public university in an outermost region with economic resources and academic performance below the national average. Starting with bivariate descriptive analyses, it moves on to multivariate analyses through structural equation models, thereby examining the joint correlation of variables related to mathematical literacy with the construct ‘academic success’ in the first year of BAM. The results reveal a dual mediating effect on women’s academic success through the chosen mathematics pathway and the grades obtained in the mathematics

entrance examination. The study demonstrates a significant correlation between mathematical literacy and academic success in the first year of the BAM degree, both in the subjects with a mathematical component and in those with a higher theoretical component, thus highlighting statistical gender differences. These findings underscore the need for a broader focus beyond gender, including baccalaureate choices in the analysis, to improve the predictions and interventions aimed at enhancing academic success in BAM programs.

**Keywords:** educational outcomes; mathematical literacy; university entrance; Business Administration and Management degree; structural equation model; mediating effect; transition to tertiary education

**Mathematics Subject Classification:** 62H15, 97B40

### Abbreviations:

Sr. No	Complete word	Abbreviation
1	Business Administration and Management	BAM
2	Structural Equation Model	SEM
3	Grade Point Averages	GPA's
4	Science, Technology, Engineering, and Mathematics	STEM
5	University of Las Palmas de Gran Canaria	ULPGC
6	Evaluación de Bachillerato para el Acceso a la Universidad (Spanish acronym)	EBAU
7	Mathematics grades in the university entrance examinations	MATHS
8	Socio-economic background	SES
9	Program for International Student Assessment	PISA
10	Admission mark	ADMISSION
11	Root Mean Square Error Approximation	RMSEA
12	Comparative Fit Index	CFI
13	Tucker Lewis Index	TLI

## 1. Introduction

In higher education, the imperative to diminish dropout rates and improve academic performance has forged a significant connection between these variables, thus requiring a deeper investigation. The negative consequences of dropout are significant for both the individuals and the institutions, thus making dropout prevention a major challenge for higher education institutions, which must improve the retention strategies, learning support, and mentoring programs [1].

Examining data from the Spanish University System, UNIVbase (Integrated University Information System), during the 2017–2018 academic year, has shown that the university student's overall dropout rate reached 21.3%, with 8.3% of students opting to switch from their initial degree choice. In the 2018–2019 academic year, the overall dropout rate increased to 22%, with 8.8% of students opting to switch from their initial degree choice. Going deeper into specific disciplines, according to UNIVbase, the dropout rate for Business Administration and Management (BAM)

degrees in Spain in the 2017–2018 academic year was 25.96%. In the following 2018-2019 academic year, it increased by one point, reaching 26.96%. Taking the latest data published in 2023 by the Ministry of Universities into account, which put the overall university dropout rate at 31.7%, this still represents a major challenge [2].

Furthermore, taking the ownership of the university into consideration, data from UNIVbase shows that in the 2017-2018 academic year, the dropout rate for BAM degrees in public universities was 27.05% as compared to 21.73% for private universities. The dropout rate is particularly significant in public universities, as it represents a loss to society of the investment that covers around 80% of the cost of a student's education. According to EUROSTAT data, in 2017, public spending to fund higher education institutions (offering bachelor's, master's and doctoral degrees) in Spain was 0.76% of GDP as compared to 1.10% of GDP for the European Union (EU) average of 28 countries. This difference represents a shortfall in public funding of 3950 million euros in 2017 [3]. Given this financial situation and the importance of efficiency in the management of public resources, we have focused this study on public universities. Beyond the financial implications, the impact extends to individual setbacks and missed opportunities, underscoring the multiple consequences of academic disengagement. Specifically, in the Canary Islands, the dropout rate for BAM studies in public universities was 31.79% for the 2018–2019 academic year.

In terms of the performance rates, data from UNIVbase shows that the rate for Social and Legal Sciences degrees, which includes BAM, was 73.91% in the 2018–2019 academic year. In public universities, the rate was lower, at 71.73%. A detailed breakdown of the results by the autonomous community showed the lowest performance in the Canary Islands, with a 64.73% rate in the same period. This data is alarming, since the Canary Islands are 9 points below in the performance rate. According to data from the Ministry of Universities (2019–2020), women are in the majority (55.2%) of enrollment in all university entrance procedures. Specifically, according to data published by the Spanish government's Ministry of Universities 59.8% of the students enrolled for degrees in Social and Legal Sciences in the 2018–2019 academic year were women. This area of education is the third most popular among women, following Health Sciences (70.3%) and Arts and Humanities (61.4%). Furthermore, given the significant presence of women in Social and Legal Sciences degrees, it is important to more specifically know what influences women's academic success, noting that the academic performance of women in BAM degrees for the 2018–2019 academic year was 75.72% as compared to 69.88% for men [4].

To increase the academic performance, it will be necessary to try to detect predictors of performance before studying at university. Beyond proposing measures for action at the university stage, it is of a vital importance to specifically know what the study patterns are in stages prior to university, with the aim of ensuring a better transition from high school to university. In order to identify and prevent the causes of dropout, it is essential to examine predictors at earlier stages of education and to intervene before students enter university. Exploring these aspects can shed important light on early intervention strategies and academic support. Several studies have suggested examining the academic performance at the university level in relation to predictors from secondary school [5,6]. In particular, in Spain, baccalaureate students typically choose either a 'scientific' or a 'humanistic and social' path, each with two tracks. The subject of mathematics, which is an integral part of both pathways, includes different content that may shape future the mathematical literacy. In addition, research suggests that the entrance exam grade serves as a promising predictor of academic success [7,8].

In this context, the primary aim of this study is to examine various predictors that may affect the educational outcomes of first-year students pursuing a BAM degree. Variables such as gender, the mathematics pathway chosen during the baccalaureate period, and the mathematics entrance exam grade are examined. Using a methodological approach based on a structural equation model (SEM), we aim to improve our understanding of reliable predictors. The findings determine the importance of mathematical literacy as a predictor variable of female academic success in BAM degrees. This knowledge will serve as a valuable tool to reduce the risk of dropping out of university. Furthermore, there is an urgent need for research in the area of social sciences in BAM degrees to address the adaptation of the student profiles to the evolving analytical skills demanded by the labor market. This research seeks to address this need and contribute to a more robust understanding of the factors that influence academic success and retention in higher education.

The rest of this paper is organized as follows. In Section 2, we present the conceptual framework and the hypotheses that guide our research, thereby focusing on the predictors of academic success in the first year of BAM degrees. Section 3 outlines the methodology, including a detailed explanation of the transition process from high school to university in Spain, the data collection process, the variables used, and the statistical techniques applied, particularly SEM. Section 4 presents the results of the bivariate and multivariate analyses, thereby providing insights into the relationships between gender, mathematical literacy, and academic success. Finally, Section 5 discusses the findings in the context of the existing literature, thereby highlighting their implications for both educational policy and practice, and concludes with suggestions for future research directions.

## 2. Conceptual framework and hypotheses

The study of academic performance in higher education continues to be of great interest, particularly in the analysis of the predictors of such success. Despite the increase in the number of students that attend university education, there are still problems with retention and the successful completion of studies based on socio-demographic characteristics [9]. Various academic and non-academic factors may influence a students' performance at university [see 10]. Delving deeper into the differences in student performance and analyzing the reasons for dropout can provide useful information for educational decision-makers to design appropriate programs and policies to reduce these gaps [1,9]. Therefore, there is a clear need for further research on the predictors of academic success in university in order to improve student performance and limit dropout at this educational level. The present study aims to focus attention on the determinants of academic success in economics and business degrees, and more specifically in first-year students.

### 2.1. Gender and first-year success

It is essential to identify the predictors of performance, both academic and non-academic, in first-year university students to ensure continuity in the educational process. The non-academic determinants include personal factors such as gender, and it is considered of great interest to analyze gender differences in academic performance [11–13]. Several studies in Western educational contexts highlighted a positive relationship between being female and the student's achievement [6,14,15], supporting that female grade point averages (GPAs) are higher than male GPAs [16]. However, some literature suggests that gender does not play a major role in explaining academic performance in higher

education [17].

Teixeira et al. [18] suggested that female students feel better prepared than male students to cope with the demands and responsibilities of higher education. Thus, the higher educational performance of women may be related to the identity of a more focused and advantageous learner, which may lead to higher levels of engagement [19]. Castagnetti and Rosti [13] showed that women performed better than men at university, although they were outperformed in the labor market, thus suggesting that this gender gap may be explained by the greater individual efforts of the female students. In this regard, Fernández-Mellizo [6] stated that females are less likely to drop out of university compared to males.

In general, there does not appear to be gender parity in Social and Legal Sciences degrees, with a percentage distribution close to 60%–40% for women in the 2018–2019 academic year [4]. Thus, the Social and Legal Sciences do not suffer from the masculinization of Science, Technology, Engineering, and Mathematics (STEM) -with only 24.8% of women- nor from the feminization of Health Sciences -with 70.3% of women-, but students are mainly female. Therefore, it seems necessary to further investigate the effect of gender on performance, thereby taking other variables that may influence this relationship in the field of Social and Legal Sciences into account.

## 2.2. *The role of mathematical literacy*

In exploring the determinants of the students' academic performance, Totty's research [20] investigated the impact of secondary education on university success. Lindberg et al. [21] expanded this perspective, and suggested that factors such as the curriculum quality and the learning environment play a pivotal role in enhancing the student's performance, especially in the field of mathematics. Furthermore, studies indicated that the academic performance of first-year university students was influenced by their prior academic achievements [22–24]. Therefore, some research examined potential strategies to enhance the success in higher education and investigated the relationship between academic performance in secondary education and grades obtained in university entrance exams, which, in turn, may affect the success rates of university graduates. Some studies suggested that high school average scores may be a more reliable predictor of university success than entrance exams [25–27]. However, national exams are also considered reliable indicators of academic success in higher education. Silva et al. [28] concluded that both secondary school grades and national exams were significant predictors of student performance and could even be considered complementary. According to these authors, teacher grades were more susceptible to assessing characteristics other than academic performance, while national examinations provided clearer insights into such aspects.

The difference in academic performance between male and females in higher education is determined by the learning processes that students encounter in the different educational programs and disciplines [29]. Focusing on a secondary education subject such as mathematics, Ní Fhloinn et al. [30] highlighted that the fear of failure in mathematics may lead some students to drop out. Laging and Voßkamp [8] found that students with better mathematics skills from secondary education performed better in BAM degrees. In particular, they concluded that the type of school leaving certificate, the overall final grade in secondary education, and the final grade in mathematics were very important predictors of mathematics performance for first-year students in business and economics degrees. Therefore, mathematics proficiency could be a predictor of academic success at university.

Gender appears to be a relevant issue when exploring the possible drivers of mathematics performance [31,32]. Females are more likely to have higher levels of negative feelings, such as

anxiety about mathematics, and lower levels of positive self-beliefs [32]. However, more research is needed on the presence or absence of gender differences in mathematics anxiety, as the literature shows different results [see 32]. According to some studies [21,32], it seems that the women's performances in mathematics appear to be comparable to that of men, despite the prevalent misconception that mathematics 'are for men and not for women', which is known as the mathematics-gender stereotype. In fact, there remains a potential impact of this stereotypic threat on the mathematics grade [33,34]. Women who perceive a stereotypic threat obtain worse scores on a difficult math test, such that the threat of a negative stereotype reduces the accuracy in the performance of difficult tasks, although not the effort exerted [35]. Eriksson and Lindholm [33] highlighted that females perform worse than males, although the effect of gender on the mathematics score depends on certain personal and situational variables. As they concluded, women with negative stereotype-based expectancies performed better the more they identified with their gender, so that the women's high gender identification protected them from negative stereotypes about the women's mathematical abilities. Thus, gender stereotypes may play an important role in the gap between male and female performances in mathematics, where females are at a disadvantage not only in secondary education [36,37], but also at the university level [34]. Gender stereotypes have been recognized as a critical factor in shaping the low representation of women in the science and mathematics fields [38].

There appears to be a limited consensus on the magnitude and direction of gender differences in mathematics achievements, and even studies include the analysis of other factors or moderators in this relationship [31]. For example, gender differences in favor of males occur when the study of mathematics is optional and increase in advanced mathematics subjects and at higher levels of education [31]. In addition, Arnold and Straten [22] provided evidence that an inadequate preparation in mathematics does not bode well for success in the first year of business studies. Similarly, Asian Chaves et al. [26] showed a positive relationship between mathematical competence attained in secondary school and academic performance in economics and business degrees.

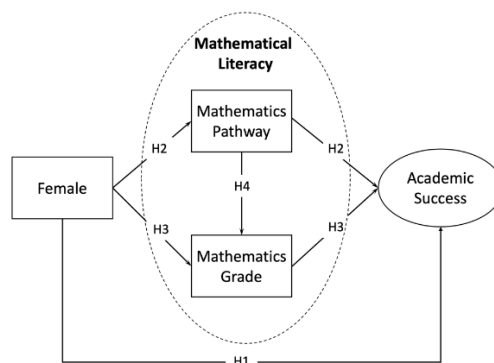
Different educational systems tend to offer different contents of mathematical competences, depending on the choice of one or another option in the baccalaureate period: (1) sciences, (2) humanities and social sciences, or (3) arts. In general, the BAM degree can be pursued from any modality of the baccalaureate, although it is usually taken from the humanities and social sciences option. In this regard, students enrolled in the science option of the baccalaureate in Spain, and not in the social sciences (which is the recommended pathway to study BAM), perform better in mathematics subjects in the first year of the degree; this may be due to a higher relational understanding in mathematics and the abstract thinking capacity [39].

Several studies have examined how taking more advanced mathematics in high school improves academic success at university [8,15,40,41]. There appears to be a relationship between previously developed mathematical skills and success in most economics and business courses, such that students who chose theoretical mathematics in the baccalaureate period have significantly better outcomes than students with a practical mathematical background [41].

### 2.3. *Research questions and hypotheses*

Given the range of the outlined factors, it becomes compelling to widen the scope of our investigation beyond simply examining the impact of gender on the academic performance. A comprehensive investigation should include the choice of the baccalaureate option, including the

mathematics pathway chosen and the grade achieved in the mathematics entrance exam, to identify their potential influence on academic success in the first year of BAM (see Figure 1). This broader perspective aims to capture the complex interplay of different elements and to shed light on the multifaceted dynamics that shape educational outcomes in the first year of BAM.



**Figure 1.** Research model and hypotheses.

As previous literature reported in the section ‘Gender and first-year success’ indicated, there is an undeniable effect between gender and academic performance; therefore, we formulate the following research hypothesis:

*H1: Female students have a better academic performance in the first year of their BAM degree than their male counterparts.*

Moreover, considering the gender perspective, and given that the mathematics pathway may also impact the performance, this paper explores whether a women’s choice of the baccalaureate pathway mediates the relationship with academic achievement in the first year of the degree. Specifically, it investigates if women studying in the science option of the baccalaureate exhibit higher academic performances in their first year at university compared to those who opted for the social science option. Additionally, the paper analyzes the significance of a high mathematical competence prior to university and its subsequent impact on academic achievement at university. Therefore, the following hypothesis is formulated:

*H2: The chosen mathematics pathway during baccalaureate influences the academic performance of female students in the first year of the BAM degree.*

At the beginning of the section on mathematical literacy, we referred to the work of authors who indicated that previous academic grades influence academic performance, and that national exams are also considered valid predictors of success in higher education. Therefore, since we propose that mathematical literacy is a mediator of the female students’ academic success at university (Figure 1), and that mathematical literacy can be measured not only by the mathematics option chosen in high school, but also by the grade obtained in mathematics in the university entrance exam, the following research hypothesis is considered:

*H3: The grade attained in the mathematics entrance exam influences the academic performance of female students in the first year of the BAM degree.*

Finally, building on our exploration of factors that influence academic success, we introduce Hypothesis 4 to examine how the type of secondary school mathematics is related to mathematics entry grades. A confirmation of this hypothesis would not only contribute to our understanding of the academic outcomes but would also increase the robustness of the ‘mathematical literacy’ construct proposed in this paper. In this line, some research [42] examined the extent to which studying advanced mathematics, as opposed to basic mathematics, can help students to enter university.

*H4: The chosen mathematics pathway during baccalaureate significantly influences the grades achieved in the mathematics entrance exam.*

Considering all the above arguments, this paper focuses on implementing a new analytical methodology based on an SEM estimation to explain the academic success of first-year university students in BAM, which is mediated by secondary school mathematics literacy and measured by the mathematics pathway of the baccalaureate attended and the mathematics grade obtained in the entrance exam, differentiating by gender.

### **3. Methods**

#### *3.1. Data and sample*

In order to carry out this study, we obtained administrative information on all incoming students in the 2018-2019 academic year in the BAM degree at the University of Las Palmas de Gran Canaria (299 students), which is a public university in an outermost region of Europe with economic resources and an academic performance below the national average. This database includes the information collected during the enrolment process, when students fill in a questionnaire that asks about their family background, which has been merged with administrative information about their access profile to the BAM degree, as well as their performance in all first-year subjects.

We focused on students who took their first-year exams to assess their academic success, excluding those who did not take the exams as they would not have a first-year grade. In addition, we did not include repeating students in our analysis because they already had a year of university experience, which could introduce other influences and confound the results. This ensures that we are accurately assessing the effect of mathematical literacy on first-year performance.

In accordance with the procedures established by the Ethics Committee of the University of Las Palmas de Gran Canaria (ULPGC), the data was anonymized by the ULPGC administration. In this way, the anonymity of the participants was guaranteed, and it was impossible to identify them. The researchers only received a numerical database from the ULPGC itself, on which we performed the relevant analyses.

#### *3.2. University entrance process in Spain*

It is important to have a clear idea of what the university entrance process is like in Spain. One of



the most common entry requirements is to have a baccalaureate and pass a general university entrance exam known as the Evaluación de Bachillerato para el Acceso a la Universidad (EBAU). This entrance exam is common to all students who have the same baccalaureate option and consists of two parts: a) compulsory and b) optional. In the compulsory section, the students take 4 subjects: Spanish Language and Literature, Spanish History, Foreign Language, and the fourth subject must be chosen according to the baccalaureate option chosen. Students who chose the Social Sciences option took 'Mathematics Applied to Social Sciences II', those who chose the Science option took 'Mathematics II', those who chose the Humanities option took 'Latin', and those who chose the Art option took 'Fundamentals of Art II'. Each of the compulsory tests is graded out of 10, with the maximum possible score being 10. In the optional section, students take examinations in subjects other than those of the compulsory phase in order to obtain a higher grade. This section is worth a maximum of 4 points. The grade obtained in the EBAU is weighted with the grade obtained in the baccalaureate in order to calculate the university entrance grade. A minimum of 4 points must be obtained for the EBAU grade to be averaged with the baccalaureate grade. If the student took the optional part of the EBAU, then the university entrance grade is calculated by adding the weighted grades obtained in the subjects of the optional part of the EBAU to the university entrance grade. The maximum admission grade is 14 points.

There are other forms of university access in Spain that do not specifically require the EBAU but do have an access grade. The rest of the students fall into one of the following categories: a) those with a Higher Technical Vocational Qualification, b) those over 25 years old who have passed the University Entrance Examination, c) those over 40 who have professional experience related to the university qualification they wish to study, d) those over 45 who have passed the University Entrance Examination, and e) foreign students with studies equivalent to the baccalaureate or recognized as equivalent to the baccalaureate. These students can enter university without taking the EBAU.

### 3.3. Variables

#### 3.3.1. Female

Administrative data on university enrollment is used for this variable. It includes the binary classification 'male' and 'female' as possible answers. The participants can only belong to one of these two groups.

#### 3.3.2. Mathematical literacy

This paper proposes this concept to group two mediating variables that could measure the mathematical literacy of future university students: mathematics pathway and mathematics grade.

With regard to the first variable, in the Spanish education system, the choice of the baccalaureate option implies the selection of the type of mathematics to be studied during the two years of this educational stage: (a) for those who choose the Science option, they should select 'Mathematics I' and 'Mathematics II', and (b) for those who choose the Humanities and Social Sciences option with the social sciences pathway, they should select 'Mathematics Applied to Social Sciences I' and 'Mathematics Applied to Social Sciences II' (those who choose the humanities pathway, like those who choose the Arts option, do not study mathematics). This variable consists of the grade obtained in either Mathematics I/II or in Mathematics Applied to Social Sciences I/II in the baccalaureate. The

participants in our study can only belong to one of these two groups. The grades range from 0 to 10 and a passing grade is obtained with a score of 5 or higher.

The mathematics grade refers to the marks obtained in the mathematics tests of the standardized university entrance examinations (MATHS), irrespective of the baccalaureate option and the pathway. The grades range from 0 to 10 and a passing grade is obtained with a score of 5 or higher.

### 3.3.3. Academic performance

In this research, the academic performance is not measured by the average grade obtained by the students, as measured in previous studies [15,23]. Instead, our study measures the academic performance using a construct derived from the final grades obtained in the assessment of learning for each first-year BAM subject. The subject grades range from 0 to 10, with a passing score of 5. The construct is termed an ‘academic success’.

### 3.3.4. Socio-economic background (SES)

The literature emphasizes the importance of including information about the students and parents, such as their living conditions, in studies that attempted to explain the first-year academic performance [43]. To address this, we estimate the SES variable by a factor analysis based on the parents’ educational attainment and occupation, thereby following a similar approach to that used by the Organisation for Economic Co-operation and Development (OECD) when implementing the Program for International Student Assessment (PISA). While we do not have the full range of information used by the OECD, these key components provide a robust basis for our SES measure. Overall, there seems to be some relationship between the socio-economic status and the academic performance in higher education, although a more in-depth analysis of this relationship is still lacking in the educational literature [44]. Therefore, SES appears in the proposed research model as a control variable that should be considered to identify its potential influence.

## 3.4. Methodology

We begin our analysis with a bivariate descriptive approach, thereby examining potential differences by gender, SES, or the type of mathematics chosen in the baccalaureate. First, we focus on differences in variables such as the average grades in EBAU and MATHS, as well as the proportion of students who chose each type of mathematics, which are events that occurred prior to entering university. Then, we repeat these comparisons for the grades obtained at the end of the first year in each of the BAM subjects. Through this is a bivariate descriptive analysis, our aim is to explore possible correlations between different explanatory variables -both those of interest and control variables- at two different stages: before entering university and after the first year of university.

Then, we proceed with a multivariate analysis by estimating SEMs. Within these models, we examine the joint correlation of the explanatory variables presented in Figure 1 with the construct variable that represents the first-year educational performance, termed an ‘academic success’. This SEM analysis examines the impact of the first stage -consisting of the pre-university access variables- on the second stage, which includes academic performance after the first year of university. In this way, we examine the interrelationship between pre-university and university outcomes. This analysis further

differentiates academic success, taking both the overall performance in the first year and the success in subjects with a more quantitative or theoretical focus into account.

The estimation of the model in Figure 1 is carried out by estimating the following system of simultaneous equations, where  $i$  refers to each of the 296 students,  $T_i$  is a dichotomous variable indicating the type of mathematics chosen by the student during baccalaureate, taking value 1 if the student chose Mathematics I/II,  $F_i$  is another dichotomous variable indicating the students' gender, taking the value 1 for females,  $MG_i$  is a continuous variable that represents the grade obtained by the student in mathematics in the University Entrance Examination,  $E_i$  is an index of the student's socio-economic status,  $S_i$  refers to the construct of academic success, and  $G_{j_i}$  are numerical variables that represent the student's grades in each of the 10 first-year subjects of the BAM.

$$\begin{aligned}
 T_i &= \alpha_1 + \beta_1 F_i + \xi_{1i} \\
 MG_i &= \alpha_2 + \beta_2 F_i + \beta_3 T_i + \beta_4 E_i + \xi_{2i} \\
 S_i &= \alpha_3 + \beta_5 F_i + \beta_6 T_i + \beta_7 MG_i + \beta_8 E_i + \xi_{3i} \\
 G_{1i} &= \alpha_4 + \beta_9 S_i + \xi_{4i} \\
 G_{2i} &= \alpha_5 + \beta_{10} S_i + \xi_{5i} \\
 G_{3i} &= \alpha_6 + \beta_{11} S_i + \xi_{6i} \\
 G_{4i} &= \alpha_7 + \beta_{12} S_i + \xi_{7i} \\
 G_{5i} &= \alpha_8 + \beta_{13} S_i + \xi_{8i} \\
 G_{6i} &= \alpha_9 + \beta_{14} S_i + \xi_{9i} \\
 G_{7i} &= \alpha_{10} + \beta_{15} S_i + \xi_{10i} \\
 G_{8i} &= \alpha_{11} + \beta_{16} S_i + \xi_{11i} \\
 G_{9i} &= \alpha_{12} + \beta_{17} S_i + \xi_{12i} \\
 G_{10i} &= \alpha_{13} + \beta_{18} S_i + \xi_{13i}
 \end{aligned}$$

All equations are linked together and the inference about them is simultaneous, unlike the independent standard regression equations. We assume the error terms ( $\xi_{1i}, \xi_{2i}, \dots, \xi_{13i}$ ) are uncorrelated, which is an important assumption for causal inference in performing the mediation analysis; however, we cannot assume a multivariate normality for the error terms. Thus, we assess the goodness of fit using the Satorra-Bentler scaled chi-squared test, which is robust to non-normality. In this way, the other goodness of fit statistics derived from the model using the chi-squared test are also robust to non-normality.

All statistical analyses are carried out using Stata 17.

## 4. Results

### 4.1. Bivariate analysis

#### 4.1.1. Entering BAM students: Grades prior to University

Tables 1–3 present the basic descriptive statistics for the 299 students who enrolled in the BAM degree during the 2018-2019 academic year. First, the tables encompass the grades achieved in the University Entrance Examination (EBAU), which is calculated by taking the weighted average of the scores of the compulsory phase standardized exams (40%) and the average of the grades of all baccalaureate subjects (60%). Then, they include the grades obtained in the mathematics tests of the standardized university entrance exams (MATHS), regardless of the baccalaureate option and path. Next, they include the admission mark (ADMISSION), which corresponds to the EBAU grade for baccalaureate students, but not for other groups such as vocational students, foreigners, transfer students, or those aged over 25. Finally, the tables also include the proportion of students who have chosen more scientific mathematics fields.

**Table 1.** Descriptive statistics, by gender, of the average score of the university entrance exam (EBAU), the mathematics tests (MATHS), and the admission (ADMISSION), and of the proportion of students who chose the science option (MathsI&II).

Gender		EBAU	MATHS	ADMISSION	MathsI&II
Male	Mean	7.06 <sup>***</sup>	5.64	6.97 <sup>***</sup>	0.37 <sup>*</sup>
	Deviation	1.08	2.41	1.12	0.49
	Coefficient of variation	0.15	0.43	0.16	1.30
	n	143	134	167	134
Female	Mean	7.43 <sup>***</sup>	5.57	7.55 <sup>***</sup>	0.25 <sup>*</sup>
	Deviation	1.56	2.26	1.21	0.44
	Coefficient of variation	0.21	0.41	0.16	1.72
	n	110	106	132	106
Total	Mean	7.22	5.61	7.23	0.32
	Deviation	1.32	2.34	1.19	0.47
	Coefficient of variation	0.18	0.42	0.17	1.46
	n	253	240	299	240

Note: Statistically significant difference in means between men and women at 1%<sup>\*\*\*</sup>, at 5%<sup>\*\*</sup> and at 10%<sup>\*</sup>.

It is worth noting that more men than women (56.5% vs. 43.5%) enrolled in this degree this academic year and that 59 students (19.7%) did not take any mathematics test. In addition, on average, women had higher scores in the EBAU (although the dispersion is higher than for men) and in the admission mark. However, women had lower (and somewhat less dispersed) grades in the mathematics tests than men (Table 1), although this difference is not statistically significant. Finally, a minority of students chose mathematics from the science option, and this minority was more pronounced among women (37% for men and 25% for women).

Additionally, there are statistically significant differences by SES, although at a lower level of

significance (Table 2). Students from an above-average SES had higher average EBAU and mathematics test scores than students from a below average SES. However, there are no statistically significant differences by SES in either the admission marks or the proportion of students who chose the science option.

**Table 2.** Descriptive statistics, by SES, of the average score of the university entrance exam (EBAU), the admission mark (ADMISSION), and the mathematics exam (MATHS), and of the proportion of students who chose the science option (MathsI&II).

SES		EBAU	MATHS	ADMISSION	MathsI&II
Above average	Mean	7.43*	5.97**	7.35	0.31
	Deviation	1.24	2.38	1.27	0.46
	Coefficient of variation	0.17	0.43	0.16	1.50
	n	106	101	129	101
Below average	Mean	7.07*	5.36**	7.14	0.32
	Deviation	1.36	2.30	1.12	0.47
	Coefficient of variation	0.19	0.40	0.17	1.45
	n	147	139	170	139
Total	Mean	7.22	5.61	7.23	0.32
	Deviation	1.32	2.34	1.19	0.47
	Coefficient of variation	0.18	0.42	0.17	1.47
	n	253	240	299	240

Note: Statistically significant difference in means by SES at 1%\*\*\*, at 5%\*\* and at 10%\*.

**Table 3.** Descriptive statistics, by type of mathematics, of the average score of the university entrance exam (EBAU), the mathematics exam (MATHS), and the admission mark (ADMISSION).

Type of mathematics		EBAU	MATHS	ADMISSION
Mathematics applied to social sciences I&II	Mean	7.43***	6.09***	7.45***
	Deviation	1.17	2.31	1.17
	Coefficient of variation	0.16	0.38	0.16
	n	163	163	163
Mathematics I&II	Mean	6.74***	4.59***	6.92***
	Deviation	1.48	2.08	1.01
	Coefficient of variation	0.22	0.45	0.15
	n	77	77	77
Total	Mean	7.21	5.61	7.28
	Deviation	1.32	2.34	1.14
	Coefficient of variation	0.18	0.42	0.16
	n	240	240	240

Note: Statistically significant difference in means by type of mathematics at 1%\*\*\*, at 5%\*\* and at 10%\*.

Regarding the type of mathematics chosen by students entering BAM, the majority of new students who took a mathematics test (163/240 = 68%) chose Mathematics Applied to Social Sciences

I&II. The EBAU grades of the students who chose this type of mathematics were higher (and with less dispersion) than the grades of those who chose Mathematics I&II. For this reason, the admission grade of those students who chose the former option was also higher (but with a slightly larger dispersion). Students who took the mathematics test with the option Mathematics I&II had the highest dispersion, and the average mark of this test was a failure, as it did not reach 5 out of 10 (Table 3).

**Table 4.** Descriptive statistics, by gender, of first-year BAM subjects' grades.

Gender		First-year BAM subjects <sup>a</sup>									
		500	501	502	503	504	505	506	507	508	509
Male	Mean	5.26**	2.44***	2.37**	3.53	3.95***	4.63***	2.37***	2.60**	3.05**	3.25***
	Deviation	2.58	2.48	2.66	3.13	2.60	3.59	3.07	3.18	3.15	2.83
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	9.2	8.6	10	10	10	10	10	9.4	8.9
	n	167	145	167	167	145	145	167	145	167	145
Female	Mean	6.10**	3.11***	2.98**	3.98	5.02***	6.01***	3.41***	3.40**	3.91**	4.38***
	Deviation	1.94	2.51	2.72	2.95	2.30	3.27	3.16	3.10	3.05	2.63
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	10	8.6	10	10	10	9.7	10	9.8	8.4
	n	132	114	132	132	114	114	132	114	132	114
Total	Mean	5.63	2.74	2.64	3.73	4.42	5.24	2.82	2.96	3.43	3.75
	Deviation	2.35	2.51	2.70	3.05	2.52	3.52	3.15	3.16	3.13	2.80
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	10	8.6	10	10	10	10	10	9.8	8.9
	<i>Proportion of zeros</i>	18.4	26.6	32.2	33.4	21.2	34.0	48.3	44.7	44.3	37.9
n <sup>b</sup>	299	259	299	299	259	259	299	259	299	259	

Note 1: <sup>a</sup> First-year BAM subjects: 500–Fundamentals of Business Management; 501–Introduction to Accounting; 502–Principles of Microeconomics; 503–Business Mathematics; 504–Introduction to Law; 505–Business Design and Organization; 506–Financial Accounting; 507–Principles of Macroeconomics; 508–Basic Statistics for Social Research; 509–History of Economics/Sociology; <sup>b</sup> Students studying the Double Degree in BAM and Law do not study subjects 501, 504, 505, 507 and 509 in the first year, so the sample for these subjects is lower.

Note 2: Statistically significant difference in means by gender at 1%\*\*\*, at 5%\*\* and at 10%\*.

#### 4.1.2. Entering BAM students: First-year grades

Tables 4–6 show the average grades for each of the BAM subjects in the first year. Table 4 differentiates by gender, Table 5 by SES, and Table 6 by the type of mathematics. The grades for the subjects range from 0 to 10, with a pass grade set at 5. All tables show that the average grade for almost all subjects is lower than 5. This pattern is the result of a significant number of zeros, which in some subjects account for more than 40% of the examinations (Table 4). This unusual scenario is due to the University's 'Progression and Continuation Regulations', which state that if the average grade for a subject is very low, then there is no re-sit option for students who have taken and failed the exam. For these students, this policy means that the next enrollment will be as expensive as the previous one. As

a result, students who do not intend to take an exam in a particular subject can choose to take it and submit a blank test. This strategic move is aimed at lowering the average grade and, ideally, preventing an increase in the cost of the next enrolment, thus contributing to a downward bias in average grades.

The female students consistently score higher than males in all subjects. On the other hand, the more quantitative the subject, the lower the grades. In fact, the subjects with the highest average grades are, in order, 500-Principles of Business Administration, 505-Business Design and Organization, 504-Introduction to Law, and 509-History of Economics/Sociology (Table 4).

In the first year of the degree, more students with a low SES entered compared to those with a high SES. However, it is the latter group that achieved higher grades in almost all subjects, with the exception of two subjects with a higher theoretical component: 504-Introduction to Law and 505-Business Design and Organization. Nevertheless, these differences based on socioeconomic background are not statistically significant (Table 5).

**Table 5.** Descriptive statistics, by SES, of first-year BAM subjects' grades.

SES		First-year BAM subjects <sup>a</sup>									
		500	501	502	503	504	505	506	507	508	509
Above average	Mean	5.68	2.96	2.95	3.94	4.35	5.08	3.12	3.40	3.64	3.86
	Deviation	2.54	2.76	2.84	3.11	2.68	3.63	3.32	3.41	3.30	2.88
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	9.5	8.6	10	10	10	10	10	9.8	8.8
	n	128	105	128	128	105	105	128	105	128	105
Below average	Mean	5.62	2.60	2.42	3.59	4.50	5.39	2.62	2.67	3.29	3.70
	Deviation	2.17	2.32	2.57	3.01	2.39	3.42	3.00	2.96	2.99	2.74
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	10	7.8	10	9.3	10	9.2	9.6	9.4	8.9
	n	168	152	168	168	152	152	168	152	168	152
Total	Mean	5.65	2.75	2.65	3.74	4.44	5.26	2.83	2.97	3.44	3.77
	Deviation	2.33	2.51	2.70	3.05	2.51	3.51	3.15	3.16	3.13	2.79
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	10	8.6	10	10	10	10	10	9.8	8.9
	n <sup>b</sup>	296	257	296	296	257	257	296	257	296	257

Note 1: <sup>a</sup> First-year BAM subjects: 500-Fundamentals of Business Management; 501-Introduction to Accounting; 502-Principles of Microeconomics; 503-Business Mathematics; 504-Introduction to Law; 505-Business Design and Organization; 506-Financial Accounting; 507-Principles of Macroeconomics; 508-Basic Statistics for Social Research; 509-History of Economics/Sociology; <sup>b</sup> The sample size in this table is lower than in Table 4 because three students did not report the occupation of either parent, preventing the calculation of their SES.

Note 2: Statistically significant difference in means by gender at 1%<sup>\*\*\*</sup>, at 5%<sup>\*\*</sup> and at 10%<sup>\*</sup>.

Finally, the minority of BAM-students who chose to study Mathematics I&II in the baccalaureate had the highest average grades in all first-year BAM subjects, with the exception of two subjects: 500-Fundamentals of Business Management and 508-Basic Statistics for Social Research, where they had the lowest grades (Table 6), although these differences are not statistically significant.

**Table 6.** Descriptive statistics, by type of mathematics, of first-year BAM subjects' grades.

Type of mathematics		First-year BAM subjects <sup>a</sup>									
		500	501	502	503	504	505	506	507	508	509
Mathematics Applied to Social Sciences I&II	Mean	5.81	2.62	2.72	3.64	4.49	5.12	2.80	2.83	3.59	3.77
	Deviation	2.27	2.46	2.71	2.93	2.50	3.58	3.11	3.23	3.23	2.86
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	9.5	8.6	10	10	10	10	10	9.8	8.9
	n	163	136	163	163	136	136	163	136	163	136
Mathematics I&II	Mean	5.37	2.97	2.87	4.27	4.62	5.86	3.03	3.41	3.52	4.11
	Deviation	2.38	2.50	2.83	3.21	2.39	3.19	3.09	3.08	2.94	2.64
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	8.8	8.6	10	9	9.6	9.5	9.6	9.4	8.8
	n	77	75	77	77	75	75	77	75	77	75
Total	Mean	5.67	2.74	2.77	3.84	4.54	5.38	2.87	3.03	3.57	3.89
	Deviation	2.3	2.5	2.7	3.0	2.5	3.5	3.1	3.2	3.1	2.8
	Min.	0	0	0	0	0	0	0	0	0	0
	Max.	10	9.5	8.6	10	10	10	10	10	9.8	8.9
	n <sup>b</sup>	240	211	240	240	211	211	240	211	240	211

Note 1: <sup>a</sup> First-year BAM subjects: 500–Fundamentals of Business Management; 501–Introduction to Accounting; 502–Principles of Microeconomics; 503–Business Mathematics; 504–Introduction to Law; 505–Business Design and Organization; 506–Financial Accounting; 507–Principles of Macroeconomics; 508–Basic Statistics for Social Research; 509–History of Economics/Sociology. <sup>b</sup> Students studying the Double Degree in BAM and Law do not study subjects 501, 504, 505, 507 and 509 in the first year, so the sample for these subjects is lower.

Note 2: Statistically significant difference in means by gender at 1%<sup>\*\*\*</sup>, at 5%<sup>\*\*</sup> and at 10%<sup>\*</sup>.

## 4.2. Multivariate analysis

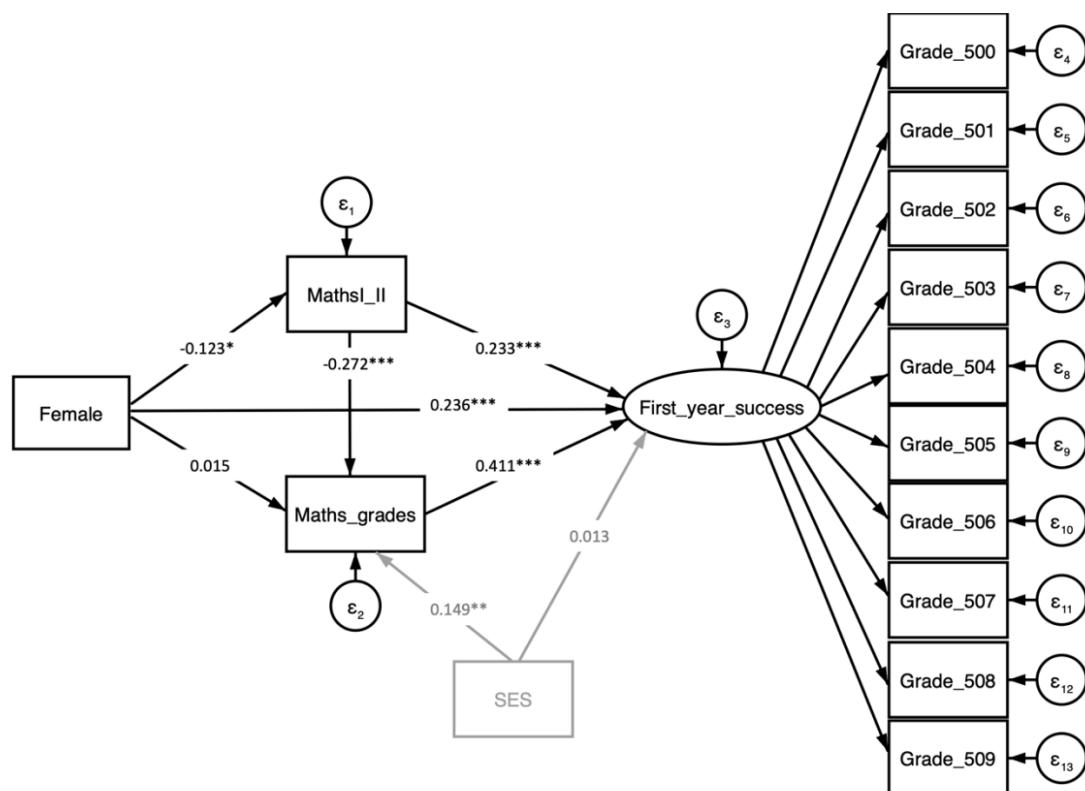
### 4.2.1. SEM modeling of first-year success

Figure 2 presents the estimations of Figure 1, thereby showing the correlation of gender with the first-year success in BAM, both directly and through the mediation of the choice of the type of mathematics and through the score in the mathematics entrance exam, taking SES into account as a control variable. Thus, it is worth noting the importance of analyzing the role of mathematical literacy, which involves constructing a mediating effect model to assess the influence of the explanatory variable on the dependent variable [45]. Similarly, Figure 3 also presents the estimations of Figure 1, thus revealing the correlation of the same explanatory variables with academic success, but specifically focusing on subjects with a higher mathematics component. Finally, Figure 4 displays the estimations of Figure 1, which shows the correlations of the same variables with academic success, this time focusing on subjects with a higher theoretical component. All figures show the standardized estimated coefficients together with their level of significance, as well as measures of the model's goodness of fit.

All the coefficients in Figure 2 are statistically significant, except those that relate gender to the mathematics grades and SES to first-year success. While all goodness-of-fit measures suggest satisfactory estimations, the Root Mean Square Error of Approximation (RMSEA) above 0.8 indicates a moderate level of accuracy. The presence of these higher estimation errors may be closely related to



the elements used to construct the academic success variable, which combines results from very different subjects. For this reason, we propose to create two additional constructs of academic success, thereby distinguishing success in subjects with a higher mathematics component from success in subjects with a higher theoretical component. This approach aims to increase precision by including more homogeneous elements in the constructs of success.



**Figure 2.** SEM estimation of academic first-year success.

N= 210

Cronbach's alpha coefficient = 0.9524

Log pseudolikelihood = -5291.8373

Chi2(72) = 282.291, p = 0.000

Standardized root mean squared residual = 0.046

Root Mean Square Error of Approximation (RMSEA) = 0.113

Comparative Fit Index (CFI) = 0.902

Tucker Lewis Index (TLI) = 0.878

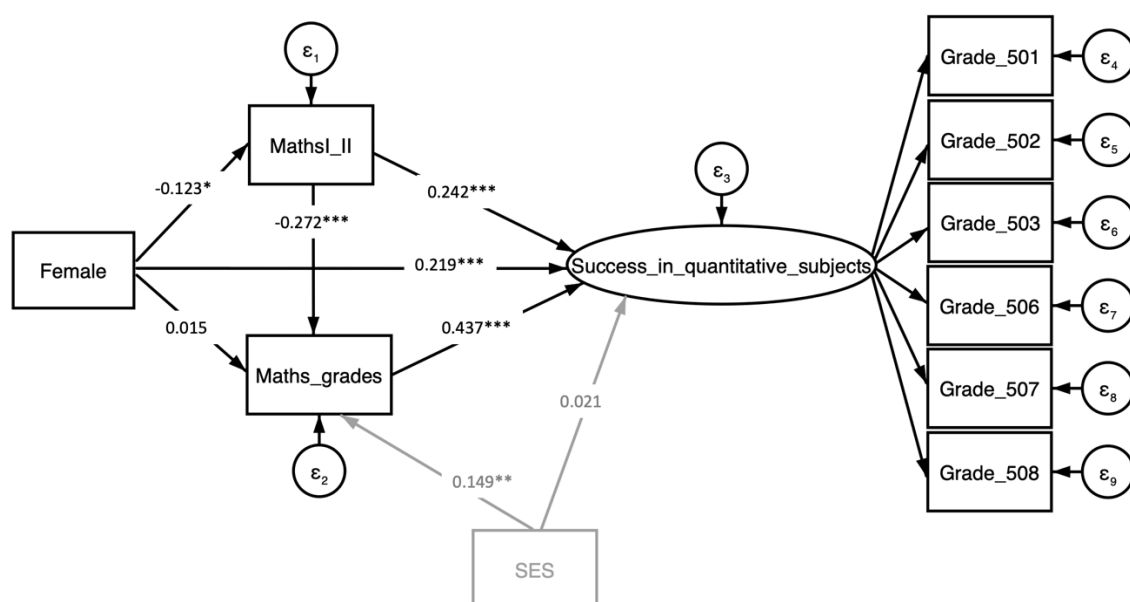
Note 1: Statistically significant coefficient at 1%\*\*\*, at 5%\*\* and at 10%\*.

Note 2: First-year BAM subjects: 500–Fundamentals of Business Management; 501–Introduction to Accounting; 502–Principles of Microeconomics; 503–Business Mathematics; 504–Introduction to Law; 505–Business Design and Organization; 506–Financial Accounting; 507–Principles of Macroeconomics; 508–Basic Statistics for Social Research; 509–History of Economics/Sociology.

Regarding the female variable, the bivariate analysis already showed that women systematically had better average grades than men. This is confirmed by the estimation of the SEM model (Figure 2), as the difference between the males and females is statistically significant, with females having a

higher academic success in the first year of BAM compared to males (0.236). Therefore, Hypothesis 1 is confirmed.

The remaining hypotheses are also fulfilled, although one of them is only partially fulfilled - Hypothesis 3- since it depends on the statistical significance of the coefficient relating gender to the mathematics grades, which, as mentioned, is not significant. Therefore, the mediation of the mathematics pathway established in Hypothesis 2 is confirmed ( $-0.123 \times 0.233 = -0.029$ ) and, despite being a minority compared to males, females who chose the science pathway and therefore took Mathematics I & II showed a slightly lower level of performance in the first year of BAM. Moreover, the mediation of mathematics grades for females established in Hypothesis 3 is indirectly confirmed through the relationship between the mathematics pathway and the mathematics grades established in Hypothesis 4 (which is also confirmed). Thus, the role of mathematics grades in the women's academic success is mediated by both the mathematics pathway chosen and the mathematics grade obtained in the university entrance exam ( $-0.123 \times -0.2722 \times 0.411 = 0.014$ ). In fact, women are less likely to choose Mathematics I & II, and as the grades in the mathematics entrance exam were lower for those who chose this option, women generally performed better in the exam and therefore had more success in the first year of BAM.



**Figure 3.** SEM estimation of academic success in subjects with a higher mathematics component.

N= 210

Cronbach's alpha coefficient = 0.9417

Log pseudolikelihood = -3598.7929

Chi2(72) = 92.664, p = 0.000

Standardized root mean squared residual = 0.031

Root Mean Square Error of Approximation (RMSEA) = 0.094

Comparative Fit Index (CFI) = 0.954

Tucker Lewis Index (TLI) = 0.932

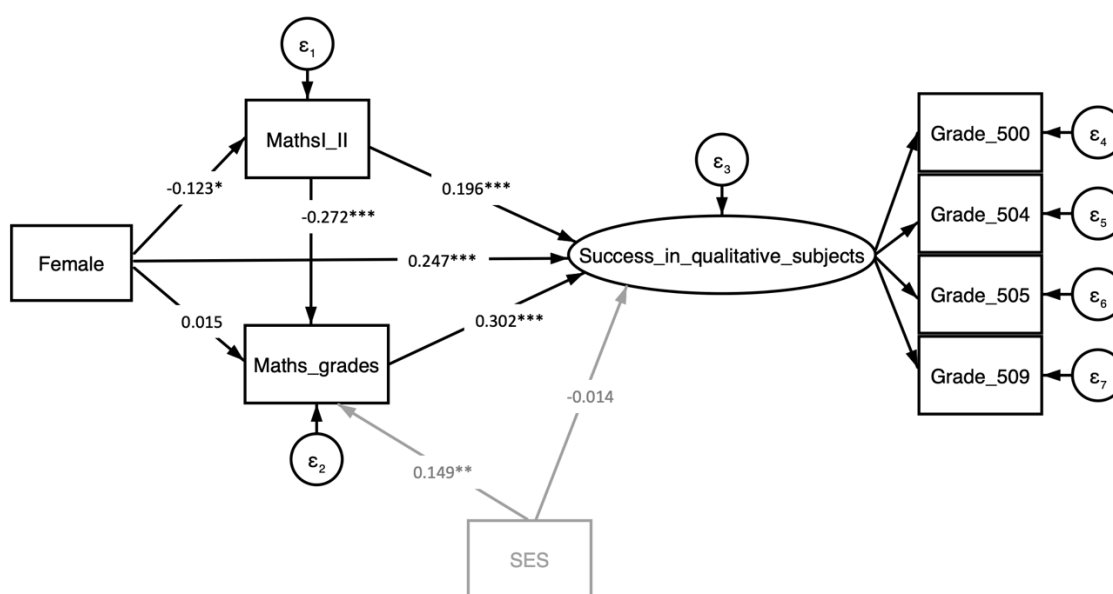
Note 1: Statistically significant coefficient at 1%\*\*\*, at 5%\*\* and at 10%\*.

Note 2: First-year BAM subjects: 501–Introduction to Accounting; 502–Principles of Microeconomics; 503–Business Mathematics; 506–Financial Accounting; 507–Principles of Macroeconomics; 508–Basic Statistics for Social Research.

#### 4.2.2. SEM modeling of first-year success in subjects with a higher mathematics component

The SEM estimations in the subjects with a higher mathematics component (Figure 3) provide results that are similar to the previous model in terms of the significance of the coefficients. The coefficients that were initially statistically insignificant in the Figure 2 model retain their insignificance in Figure 3, while those that were significant in Figure 2 remain so in Figure 3. In addition to this consistency, there is an improvement in the goodness of fit as the RMSEA is lower, although still above the benchmark of 0.8. Therefore, in the case of the subjects with a higher mathematics component, Hypothesis 1 (0.219), Hypothesis 2 ( $-0.123 \times 0.242 = -0.030$ ), and Hypothesis 3 ( $-0.123 \times -0.272 \times 0.437 = 0.015$ ) are also confirmed, the latter being mediated by Hypothesis 4 ( $-0.272$ ).

#### 4.2.3. SEM modeling of first-year success in subjects with a higher theoretical component



**Figure 4.** SEM estimation of academic success in subjects with a higher theoretical component.

N= 210

Cronbach's alpha coefficient = 0.9056

Log pseudolikelihood = -2767.387

Chi2(72) = 15.431, p = 0.421

Standardized root mean squared residual = 0.024

Root Mean Square Error of Approximation (RMSEA) = 0.008

Comparative Fit Index (CFI) = 0.999

Tucker Lewis Index (TLI) = 0.999

Note 1: Statistically significant coefficient at 1%\*\*\*, at 5%\*\* and at 10%\*.

Note 2: First-year BAM subjects: 500–Fundamentals of Business Management; 504–Introduction to Law; 505–Business Design and Organization; 509–History of Economics/Sociology.

Figure 4 shows the SEM estimation in the subjects with a higher theoretical component. Again, the results are similar to the previous models in terms of the significance of the coefficients. In addition, this model shows the best fit of all, as the RMSEA is lower and even well below the benchmark of 0.8.

Therefore, in the case of subjects with a higher theoretical component, Hypothesis 1 (-0.247), Hypothesis 2 ( $-0.123 \times 0.196 = -0.024$ ), and Hypothesis 3 ( $-0.123 \times -0.272 \times 0.302 = 0.010$ ) are confirmed, the latter again mediated by Hypothesis 4 (-0.272).

In terms of the control variables, all models (Figures 2–4) show that socio-economic background is no longer a relevant variable in explaining differences in academic performance at the university, although it is still positively correlated with the mathematics grades before entering university.

In conclusion, the multivariate analysis confirms that female students perform better than their male counterparts in the first year of their BAM degree, driven by their mathematical competence, with a difference of 0.221 in favor of women for overall academic success, 0.204 for subjects with a higher mathematics component, and 0.233 for subjects with a higher theoretical component.

## 5. Discussion

The low success rates and high failure rates in the first year of the BAM studies are concerning and lead to high dropout rates. Educational institutions need to address this issue by focusing on strategies to reduce the first-year dropout rates. In addition, these studies may influence the public policy and improve the effectiveness with which educational institutions, particularly universities, are run. From this perspective, dropping out of a public university represents a loss of public resources that the state cannot afford to lose. Therefore, mechanisms to reduce this dropout must be identified. Indeed, low first-year pass rates and high failure and subsequent dropout rates in most BAM subjects are worrying. To address this need, this paper analyzed the role of mathematical literacy in the academic success of first-year female BAM students. This research focused on determining the importance of mathematical literacy as a predictor variable of female academic success in BAM degrees.

This research confirmed previous studies [14,18] that female students performed better in BAM degrees, supporting Hypothesis 1 about the positive effect of gender on academic performance. While this relationship was confirmed, the study also introduced a new methodological model that incorporated additional mediating variables to better predict academic performance. In this sense, the research model presented the mediating role assigned to the variable ‘Mathematical literacy’ in the female academic success. This concept included two variables: 1) mathematics pathway and 2) mathematics entrance grade. First, according to Laging and Voßkamp [8] and Black and Schofield [46], the present study noted that female students with a better mathematical knowledge from secondary school performed better in BAM degrees. Specifically, the female BAM students who chose Mathematic I and II (science pathway) in the baccalaureate had better grades in the subjects in the BAM degree. Thus, the mathematics pathway chosen in the baccalaureate mediates the results of the female academic performance. In addition, confirming Opstad [41], female students who chose the science pathway displayed a better knowledge of mathematical skills and therefore performed better in university subjects, as they may have mastered complex mathematical content.

Second, the present research presents Hypothesis 3, which proposed the mediating role of the mathematics entrance grade in female academic success. Hypothesis 3 was partially confirmed because the direct relationship between the mathematics entrance grade and the academic success was confirmed, but the direct relationship between females and mathematics entrance grade is not. Therefore, female students did not achieve better grades in the mathematics entrance exam, which is in line with results of some previous research. Thus, a gender gap in the mathematics performance

exists when the mathematical skills are assessed through a performance test, such as the university entrance exam, and males tend to outperform females; however, in the first year of BAM, females obtain better results because the teaching methodologies may influence their performance [47].

Although Hypothesis 3 yielded unexpected results, Hypothesis 4 was confirmed, thus showing a direct and negative relationship between the choice of mathematics pathway in the baccalaureate and performance on the university mathematics entrance exam. This means that students who chose the science option tend to score lower on this entrance exam but surprisingly performed better academically in the first year of university. The results of the present study established the direct relationship between the mathematics pathway and the mathematics entrance exam. This direct relationship is an important finding for the proposed research model, as it confirmed that there is a relationship between gender and entrance exam grade, but through the mathematics pathway chosen. Therefore, it can be concluded that the mathematics pathway in the baccalaureate acts as a mediating variable between gender and the mathematics entrance exam grade, which in turn influences academic success. Through the proposed SEM, our methodological approach confirmed that female students who entered the BAM program with the Social Science mathematics pathway performed worse than those with the Scientific mathematics pathway [15].

Finally, it should be noted that all the previous hypotheses were also confirmed when the type of subject studied in the first year of BAM was taken into account, thus distinguishing between subjects with a higher mathematical component and those with a higher theoretical component. It should be noted that it was confirmed that mathematical competence affected the performance of both types of subjects. Although the influence was greater in subjects with a higher mathematics component, the difference in the estimated values was very small. This result indicates that the influence of mathematical literacy goes beyond the mathematical technique, but rather achieves a higher relational understanding of mathematics and the ability to think abstractly [39].

In addition, given our estimated SES, the socio-economic background does not seem to have a direct influence on the academic performance at university level. However, it does appear to be positively correlated with pre-university mathematics scores. In this respect, the meta-analysis by Rodríguez-Hernández et al. [44] indicated that the relationship between SES and university performance was relatively weak. Instead, previous grades, college experience, and employment situations were more closely associated with achievement than SES.

## 6. Conclusions

The most important finding of the present study was that we showed a correlation between mathematical literacy and academic success in the first year of BAM, with statistically significant differences by gender. This conclusion should have a direct impact on the guidance given to students in their choice of pathways in the baccalaureate. Furthermore, these results should lead to a profound reflection on possible changes in the content of Mathematics for Social Sciences I & II to ensure the optimal academic performance of future BAM students. The current mathematics content of the Social Sciences option in the baccalaureate may not provide students with the level of mathematical competence required for their desired degree. Our methodological approach, which was validated by the proposed SEM, confirmed that students who entered the BAM program that studied Mathematics Applied to Social Sciences I & II had a lower academic performance than those who followed the Science pathway. This discrepancy suggests that the frustration experienced by students in their first

year of study may lead to a decision to drop out, even though the lack of competence is not their responsibility but that of the formal secondary education curriculum. Public educational institutions must acknowledge this responsibility and make decisive changes to address this problem.

Beyond the individual consequences, this study has a considerable relevance for public policy decisions in terms of the overall efficiency of the education system and, more specifically, the university system. From a broader perspective, the dropout of a student from a public university degree represents a loss of public resources that the state cannot afford. Therefore, it is imperative to identify mechanisms aimed at reducing dropout rates.

Furthermore, a notable research contribution of this paper lies in the introduction of a strong methodological approach: SEM estimation. This model validated the mediating role of two different predictors of academic performance at university. The results of this research model highlight the importance of mathematical literacy as a transversal skill and urge serious consideration of its role in improving student performance.

The study highlights the need to enhance preparatory education before university, specifically by offering advanced mathematical skills during secondary school. Unlike Kotlikoff et al. [48] suggestion that pre-college courses may not greatly impact university performance, this research argues for a more comprehensive and sustained approach to improve the mathematical literacy from secondary school. Short-term interventions, such as short pre-university courses, are unlikely to address this deficiency. Therefore, it is essential to reassess the impact of specific courses with a mathematical content offered in the early weeks of the first semester of the academic year. An evaluation is needed to determine whether the deficit in mathematical literacy at the secondary school level can be mitigated by the investment made by universities in providing additional mathematical content for BAM degrees.

As a future line of research, we will explore the application of matching techniques to further investigate the causal relationships between mathematical literacy and academic success. This approach may provide deeper insights into the effectiveness of different educational pathways and their impact on a student's performance.

### **Author contributions**

Inmaculada Galván-Sánchez: Conceptualization, Funding Acquisition, Methodology, Writing–original draft preparation, Writing–review & editing; Alexis J. López-Puig: Conceptualization, Funding Acquisition, Methodology, Formal Analysis, Writing–original draft preparation, Writing–review & editing; Margarita Fernández-Monroy: Conceptualization, Funding Acquisition, Methodology, Writing–original draft preparation, Writing–review & editing; Sara M. González-Betancor: Conceptualization, Funding Acquisition, Methodology, Formal Analysis, Writing–original draft preparation, Writing–review & editing. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

Prof. Sara M. González-Betancor is one of the Guest Editors of special issue “Statistical Methods in the Economics of Education” for AIMS Mathematics. She was not involved in the editorial review and the decision to publish this article. All authors declare no conflicts of interest in this paper.

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