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Mathematics Anxiety in First-Year Engineering Students: Psychometric Evidence Using the Abbreviated Mathematics Anxiety Scale (AMAS)

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Abstract*– Anxiety about mathematics is a significant barrier to academic success in engineering education; however, its internal organization and contextual determinants during the transition to the first year of university are not yet fully understood. The present study examined mathematical anxiety in first-year engineering students using a person-centered approach and multivariate analysis, with the aim of capturing its heterogeneity and cumulative nature. A cross-sectional study was conducted with 293 first-year students enrolled in engineering programs in Honduras, who were assessed using the Abbreviated Math Anxiety Scale (AMAS). Descriptive analyses, latent profile analysis (LPA), multinomial logistic regression, linear regression, and mediation models were applied. The results showed moderate levels of math anxiety, with significantly higher activation in assessment contexts compared to learning situations. The LPA identified three distinct profiles of math anxiety—low, moderate, and high—revealing a heterogeneity that is not captured by overall averages. Profile membership was significantly associated with gender, but not with age. Contextual variables such as perception of mathematical performance, avoidance of mathematical activities, and mathematical anxiety since school age were consistently related to higher anxiety profiles. Mediation analysis showed that school anxiety influences university avoidance both directly and indirectly through current mathematical anxiety, which emerged as the main predictor of belonging to latent profiles. These findings conceptualize math anxiety as a structured and contextual phenomenon, with direct implications for early detection, academic support, and retention in engineering programs.

Keywords-- Math anxiety; Engineering education; Latent profile analysis; Student retention; First-year college students.

INTRODUCTION

Mathematical anxiety has been conceptualized as a multifaceted phenomenon that integrates cognitive, emotional, and behavioral components and develops progressively through iterative cognitive evaluations of environmental stimuli and somatic states[1]. Beyond its psychological dimension, math anxiety involves physiological and psychosocial processes that interact dynamically over time, shaping a complex response to mathematical demands[2].

From a cognitive perspective, math anxiety manifests itself through excessive worry and intrusive thoughts that interfere with mathematical processing. Students with high levels of math anxiety often experience difficulty suppressing these thoughts, which reduces cognitive efficiency and negatively affects academic performance [3], [4]. These cognitive responses are reinforced by negative beliefs and evaluations about one's own mathematical competence, which contribute to the maintenance of anxiety and facilitate the adoption of maladaptive behaviors [5].

At the behavioral level, one of the most consistent expressions of math anxiety is the avoidance of math-related tasks, courses, and contexts. This pattern of avoidance not only limits exposure to learning experiences but is also associated with reduced participation in STEM courses and lower academic performance in these areas [6], [7]. In higher education contexts, these behaviors can have direct implications for academic trajectories and retention in highly quantitative programs, such as engineering.

Various theoretical frameworks have attempted to explain the development and persistence of math anxiety. The value-control theory proposes that math anxiety emerges from the interaction between perceptions of control over performance and the value assigned to mathematics. From this perspective, students with high mathematical self-concept and high valuation of the usefulness of mathematics tend to have lower levels of anxiety, while those with decreasing perceptions of control and value show a progressive increase in anxiety [8].

Complementarily, the Biopsychosocial Model of Dynamic Development emphasizes the continuous interaction between environmental factors (such as teaching style and teacher attitudes), intrinsic factors (including neurocognitive predispositions), and basic numerical cognition processes, underscoring the complexity and variability of the development of math anxiety [9].

This biopsychosocial approach integrates key variables such as mathematical self-efficacy, mathematical identity, and perceived usefulness, which jointly influence both the development of quantitative skills and the experience of mathematical anxiety. From this model, strengthening self-efficacy and a positive mathematical identity is considered a central mechanism for reducing anxiety and improving mathematical performance[10].

In the specific context of engineering education, multiple studies have documented that first-year students often experience moderate levels of math anxiety, with particularly high intensity in academic assessment situations[11], [12]. Anxiety about math assessment, associated with exam anticipation and receiving grades, has been consistently identified as the most intense form of math anxiety in engineering students[13], [14].

This response is influenced by various factors, including the perception of mathematics as an inherently difficult subject, previous experiences of failure, and traditional teaching styles, as well as classroom culture and social stereotypes associated with performance in mathematics [15], [16].

Empirical evidence also shows that math anxiety negatively affects performance in both math and science, and that it is closely linked to psychosocial variables such as self-efficacy, interest in STEM, and sense of academic belonging, which together influence student engagement and retention in engineering careers [18]. In this regard, improving mathematical self-efficacy has been identified as a key objective for reducing anxiety and promoting more stable academic trajectories in STEM contexts.

In recent years, person-centered approaches, such as Latent Profile Analysis (LPA), have made it possible to identify different student profiles based on their levels of math anxiety, performance, and associated emotions. Previous studies have described profiles such as "highly anxious," "performance anxious," and "calm," as well as more complex combinations that integrate general anxiety, test anxiety, and math anxiety [19], [20].

These approaches have shown that the interaction between math anxiety and variables such as self-efficacy, resilience, and motivation significantly explains differences in math performance and academic adjustment [21]. The identification of specific profiles also allows for the design of personalized interventions aimed at addressing the needs of students at greater academic risk [22], [23], [24].

Finally, a growing body of research has explored interventions aimed at reducing math anxiety, including approaches based on games, mindfulness, and growth mindset. Evidence suggests that interventions focused on emotional regulation and cognitive support are effective in reducing math anxiety and improving performance, especially when implemented consistently and in older students [25], [26], [27]. However, the effectiveness of these strategies depends largely on early detection and a keen understanding of the patterns of math anxiety present in students, particularly at critical stages of academic transition such as entering college.

From a theoretical perspective, much of the literature has addressed math anxiety from variable-centered approaches, privileging average levels and global associations, which limits understanding of its internal heterogeneity and the contextual mechanisms that sustain it in specific populations such as first-year engineering students. In this sense, there is a need to move toward models that integrate person-centered approaches and multivariate analyses, allowing for the identification of differentiated configurations of math anxiety and its articulation with previous experiences, performance perceptions, and avoidance behaviors.

The theoretical contribution of this study lies in proposing and evaluating an integrated analytical framework that conceptualizes math anxiety as a structured, cumulative, and contextually situated phenomenon during the first year of university engineering studies, broadening the understanding of its implications for early academic adaptation and student retention.

In this context, the objective of this study was to examine math anxiety in first-year engineering students, identifying latent profiles of math anxiety and analyzing their association with relevant sociodemographic and contextual variables, in order to provide empirical evidence to guide strategies for early detection, academic support, and student retention in engineering programs.

METHODS

Study design. A cross-sectional study with a descriptive and analytical approach was conducted to examine levels of math anxiety among first-year engineering students. The study is part of the analysis of math anxiety as a relevant element in early academic adaptation processes and potentially associated with student retention. The Abbreviated Math Anxiety Scale (AMAS) was used to measure the construct, whose psychometric adequacy was evaluated as part of the methodological rigor prior to the interpretation of the results.

Context and period of the study. The research was conducted in Honduras with students enrolled in different engineering programs. The institution follows a traditional lecture-based educational model with high-stakes summative assessment, a pedagogical structure that has been associated with elevated evaluative anxiety in engineering students [8], [11]. This context is relevant for interpreting the anxiety levels observed, particularly the significantly higher activation recorded in assessment situations relative to everyday learning contexts. Data collection took place during January 2026, coinciding with the academic admission period, considered a critical stage of transition to higher education in majors with high mathematical demands.

Participants. The study population consisted of first-year students enrolled in an engineering degree program at the time of data collection. Only those participants who accepted the informed consent and completed the entire assessment form were included. No additional exclusion criteria related to age or gender were established.

Sampling and sample size. Convenience sampling was used, including all students who responded to the questionnaire during the application period. Initially, 318 responses were recorded. As part of data quality control, a cleansing procedure based on the time taken to complete the form was applied, with the aim of excluding invalid response patterns. Cases below the 5th percentile and above the 95th percentile of response time, corresponding to excessively fast and excessively slow responses, were eliminated. After this process, the final analytical sample consisted of 293 students.

Data collection procedure. The information was collected using an online form developed in Microsoft Forms, using an institutional account. The questionnaire was self-administered and anonymous, without the presence of teachers or academic staff during its application, to reduce social desirability bias and evaluative pressure. The platform was configured to prevent the submission of incomplete forms, ensuring the absence of missing data in the variables analyzed.

Variables and instrument. The main variable in the study was math anxiety, assessed using the Abbreviated Math Anxiety Scale (AMAS). The scale consists of nine items with a five-point Likert-type response format (1 = low anxiety, 5 = high anxiety), which assess experiences of anxiety associated with both math learning situations and assessment contexts. The learning anxiety subscale (items 1–5) covers situations such as studying for a math exam, working on homework, watching a teacher solve a problem, and learning new mathematical content. The assessment anxiety subscale (items 6–9) covers situations such as taking a math test, receiving the graded exam, being asked to solve a problem on the board, and thinking about an upcoming math exam. For analytical purposes, overall math anxiety scores were calculated, as well as subscale scores corresponding to the dimensions of anxiety about math learning and anxiety about math assessment. The Likert items were treated as continuous variables in the statistical and psychometric analyses.

As part of methodological quality control, the psychometric properties of the instrument were evaluated in the sample studied. The overall internal consistency of the scale was high, with a Cronbach's alpha coefficient of 0.917. At the subscale level, the dimension of anxiety about learning mathematics had a Cronbach's alpha of 0.898 and a McDonald's omega coefficient of 0.899, while the dimension of anxiety about mathematical assessment had a Cronbach's alpha of 0.878 and a McDonald's omega of 0.884.

The factorial structure of the instrument was examined using confirmatory factor analysis, specifying a model with two correlated factors. The overall fit of the model was evaluated using multiple goodness-of-fit indices, including the chi-square test ($\chi^2(26) = 102$, $p < .001$), the Comparative Fit Index (CFI = 0.955), the Tucker–Lewis Index (TLI = 0.937), and the Root Mean Square Error of Approximation (RMSEA = 0.0996), with a 90% confidence interval between 0.0797 and 0.120. Additionally, the convergent validity of the model was examined using the average extracted variance (AVE), obtaining values of 0.691 for the subscale of anxiety about learning mathematics and 0.608 for the subscale of anxiety about mathematical assessment. Discriminant validity was assessed using the HTMT index, with a value of 0.773.

Additionally, basic sociodemographic information was collected, including age, recorded as a continuous variable in years, and sex, coded as 1 for males and 2 for females. For subgroup analyses, age was categorized into three groups defined based on the empirical distribution of the sample and academic criteria: early entry (≤18 years), typical entry (19–24 years), and non-traditional entry (≥25 years). Three context questions were also included related to the perception of performance in mathematics, avoidance of mathematical activities, and perceived mathematical anxiety since the school period, with the purpose of contextualizing the levels of anxiety observed at the time of first university entry.

Statistical analysis. Statistical analyses were performed to examine the levels and patterns of math anxiety and its association with sociodemographic and contextual variables in first-year engineering students. All analyses were performed using Jamovi (v. 2.7.12.0). Descriptive statistics (mean, standard deviation, median, range, and 95% confidence intervals) were calculated for the total math anxiety score and its dimensions, as well as frequencies and percentages for sociodemographic variables.

To identify different profiles of math anxiety, a Latent Profile Analysis (LPA) was applied using the AMAS items treated as continuous variables. The models were compared using log-likelihood, AIC, BIC, CAIC, SABIC, and entropy, considering criteria of fit, classification quality, and interpretability. The associations between latent profiles and sociodemographic variables were examined using a three-step approach (BCH/DCAT), reporting χ^2 and Cramér's V tests. The relationship between profiles and contextual variables was analyzed using multinomial logistic regression, evaluating model fit with AIC and McFadden's R^2.

Finally, a multiple linear regression model was estimated to analyze the association between contextual variables and total math anxiety, as well as a mediation analysis to evaluate direct, indirect, and total effects using 95% confidence intervals.

Control of biases. Various strategies were implemented to minimize possible sources of bias, including anonymity of responses, self-administered application of the questionnaire, exclusion of extreme responses based on completion time, and use of a standardized and previously validated instrument.

Ethical considerations. The study was approved by an institutional ethics committee. All participants gave their informed consent prior to completing the questionnaire. Participation was voluntary, anonymous, and without financial compensation, ensuring confidentiality and the exclusive use of data for academic and research purposes.

Funding. The study did not receive external funding.

Results

Sample characteristics

The sample consisted of 293 first-year students enrolled in engineering programs. No missing data were recorded in the sociodemographic variables analyzed.

The participants' age was 22.1 years (SD = 6.36) on average, with a median of 19 years and a range between 15 and 48 years, reflecting the coexistence of early-entry and non-traditional students. For subgroup analyses, age was categorized into three groups defined based on academic criteria and the empirical distribution of the sample: early entry (≤18 years), typical entry (19–24 years), and non-traditional entry (≥25 years). 40.3% of students belonged to the early entry group, 34.8% to the typical entry group, and 24.9% to the non-traditional entry group.

In terms of gender, 67.2% of the sample consisted of women (n = 197) and 32.8% of men (n = 96), showing a higher female participation among first-year students in the engineering programs included in the study (Table 1).

TABLE 1
SOCIODEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE
(N =293)

Variable	Category / Statistic	n	%
Age (years)	Mean (SD)	22.1	—
	Median	19.0	—
	Minimum – Maximum	15 – 48	—
Age group	Early entry (≤18 years)	118	40.3
	Typical entry (19–24 years)	102	34.8
	Non-traditional entry (≥25years)	73	24.9
Sex	Men	96	32.8
	Women	197	67.2

Note. No missing data were observed for the sociodemographic variables.

Descriptive levels of math anxiety

Levels of math anxiety showed moderate variability and a differentiated pattern depending on the type of situation evaluated. The total math anxiety score (AMAS total score) had a mean of 2.80 (SD = 0.93), with a 95% confidence interval between 2.69 and 2.91, placing it in the middle range of the scale.

When analyzing the specific dimensions, it was observed that anxiety about math assessment was considerably higher than anxiety associated with math learning. In particular, evaluation anxiety reached a mean of 3.34 (SD = 1.11; 95% CI = 3.21–3.46), while anxiety about mathematical learning had a mean of 2.37 (SD = 0.93; 95% CI = 2.26–2.48).

The medians reinforced this trend (assessment: Median = 3.50; learning: Median = 2.20), indicating that assessment situations generate higher levels of anxiety than everyday learning activities (Table 2).

TABLE 2.
DESCRIPTIVE STATISTICS OF MATHEMATICS ANXIETY SCORES

	Mean	95% CI		Median	SD
		Lower	Upper		
AMAS_TOTAL	2.80	2.69	2.91	2.78	0.928
EvaluationAnx	3.34	3.21	3.46	3.50	1.112
LearningAnx	2.37	2.26	2.48	2.20	0.930

Identification of latent profiles of math anxiety

With the aim of identifying different patterns of math anxiety, a Latent Profile Analysis (LPA) was performed using the nine items of the AMAS treated as continuous variables. Solutions with different numbers of profiles were compared using multiple fit indices, including AIC, BIC, CAIC, SABIC, entropy, and log-likelihood.

Although the BIC reached its minimum value in a two-profile solution, other relevant indicators—particularly the AIC, SABIC, and entropy—favored a three-profile solution. In addition, the three-class solution showed better separation between profiles, high classification accuracy, and greater theoretical interpretability, allowing us to distinguish between low, moderate, and high anxiety profiles. Based on these criteria and consistency with subsequent analyses, the three latent profile solution was retained.

Profile 1 (low anxiety) was characterized by consistently low levels of anxiety on all AMAS items, both in learning and assessment contexts. Profile 2 (high anxiety) showed high and generalized levels of anxiety in learning situations and math assessments. Finally, Profile 3 (moderate anxiety) showed intermediate levels, with a more situational and less generalized anxious response. Overall, the three-profile solution allowed us to accurately capture the heterogeneity of math anxiety in the sample.

Association between latent profiles of math anxiety and sociodemographic variables

The association between latent profiles and sociodemographic variables was examined using a three-step analysis (BCH/DCAT). Statistically significant differences by gender were identified in the distribution of profiles ($\chi^2(2)$ = 17.135, p = 0.00019), with a moderate effect size (V = 0.242). Pairwise contrasts indicated significant differences between Profile 1 and Profile 2 ($p < 0.001$) and between Profile 1 and Profile 3 ($p < 0.01$), while no significant differences were observed between Profiles 2 and 3.

In contrast, no significant differences were identified according to age group ($\chi^2(4) = 1.658$, $p = 0.798$; $V = 0.053$), nor in the pairwise contrasts between early, typical, and non-traditional entry, suggesting that the organization of math anxiety into profiles is more associated with gender than with age at university entry.

Contextual variables associated with mathematical anxiety profiles

The association between latent profiles and contextual variables was examined using multinomial logistic regression, using as predictors the perception of performance in mathematics (Intro1), avoidance of mathematical activities (Intro2), and perceived mathematical anxiety since school (Intro3). Profile 1 (low anxiety) was used as the reference category. The model showed an adequate fit (AIC = 488; $R^2McFMcF = 0.256$).

Compared to Profile 1, belonging to Profile 2 was significantly associated with a lower perception of mathematical performance ($\beta = -1.024$, $p = 0.001$), greater avoidance of mathematical activities ($\beta = 0.714$, $p = 0.008$) and greater mathematical anxiety since the school period ($\beta = 1.672$, $p < 0.001$). Similarly, belonging to Profile 3 was also associated with lower perceived performance ($\beta = -0.493$, $p = 0.037$), greater avoidance ($\beta = 0.471$, $p = 0.024$), and greater prior anxiety ($\beta = 0.547$, $p = 0.011$) (Table 3).

TABLE 3.
MULTINOMIAL LOGISTIC REGRESSION PREDICTING LATENT PROFILE MEMBERSHIP

Predictor	**Profile 2 vs. 1 (Estimate, *p*)**	**Profile 3 vs. 1 (Estimate, *p*)**
Perceived mathematics performance (Intro1)	−1.024 (**0.001**)	−0.493 (0.037)
Avoidance of mathematics-related activities (Intro2)	0.714 (0.008)	0.471 (0.024)
Mathematics anxiety since school (Intro3)	1.672 (**<0.001**)	0.547 (0.011)
Intercept	−4.066 (0.014)	−0.549 (0.642)

Note. Reference category = Profile 1. Values are unstandardized estimates. Only statistically relevant predictors are displayed to improve readability.

Association between contextual variables and total math anxiety

A linear regression model was estimated to examine the relationship between contextual variables and total math anxiety scores. The model explained approximately 49.8% of the variance ($R = 0.706$; $R^2 = 0.498$).

Perception of math performance (Intro1) was negatively and significantly associated with total math anxiety ($\beta = -0.212$, $p < 0.001$). In contrast, both avoidance of math activities (Intro2) ($\beta = 0.162$, $p = 0.001$) and math anxiety since school age (Intro3) ($\beta = 0.376$, $p < 0.001$) showed positive and significant associations, with the latter being the strongest predictor.

Mediation analysis

A mediation model was estimated to assess whether total math anxiety mediated the relationship between math anxiety since school (Intro3) and avoidance of math activities (Intro2). A significant indirect effect was identified ($\beta = 0.167$, $z = 4.06$, $p < 0.001$; 95% CI [0.082, 0.235]), indicating partial mediation.

In addition, significant direct effects were observed of school anxiety on total math anxiety ($\beta = 0.664$, $p < 0.001$), of total math anxiety on avoidance ($\beta = 0.251$, $p < 0.001$), and a residual direct effect of school anxiety on avoidance ($\beta = 0.451$, $p < 0.001$). The total effect was high and significant ($\beta = 0.617$, $p < 0.001$).

Predictors of the math anxiety profile

Finally, a multinomial logistic regression model was estimated to evaluate the joint contribution of total math anxiety and sociodemographic variables to membership in latent profiles, using Profile 1 as a reference. The model showed an excellent fit (AIC = 66.8; $R^2McFMcF = 0.920$).

Total math anxiety emerged as a strong and significant predictor of belonging to higher anxiety profiles (Profile 2 vs. 1: $\beta = 44.49$, $p < 0.001$; Profile 3 vs. 1: $\beta = 14.35$, $p < 0.001$). In contrast, neither math anxiety since elementary school nor gender showed significant direct associations with belonging to the profiles once total math anxiety was controlled for, indicating that the latter is the main determinant of classification into latent profiles.

DISCUSSION

This study examined math anxiety in first year engineering students, integrating a descriptive, analytical, and advanced modeling approach to understand its internal organization, latent profiles, and relationship with contextual variables relevant to early academic trajectories. Taken together, the results offer a structured view of math anxiety as a heterogeneous, contextual, and cumulative phenomenon, with direct implications for adaptation and retention processes in engineering programs [3], [6].

First, descriptive levels of math anxiety showed that, on average, students experience moderate levels of anxiety, with a clear differentiation between learning and assessment contexts. The greater intensity observed in assessment situations suggests that math anxiety in first-year university students is mainly triggered in scenarios involving academic judgment, rather than in everyday learning activities. This pattern is consistent with previous studies in engineering populations that report moderate levels of math anxiety, with a particular intensification in formal assessment contexts [11], [12], [13], [14]. Likewise, these results align with approaches that conceptualize math anxiety as a situationally sensitive response, exacerbated when control and academic performance are perceived as threatened [4], [8].

A key finding of the study was the identification of three latent profiles of math anxiety, which allows us to move beyond one-dimensional approaches based solely on averages or arbitrary cut-off points. The existence of low, moderate, and high anxiety profiles supports the idea that first-year engineering students are not a homogeneous group in terms of their emotional relationship with mathematics, in line with research that has used person-centered approaches to capture the heterogeneity of math anxiety [19], [20], [21]. In particular, the identification of an intermediate profile is especially relevant from a preventive perspective, as it represents a group susceptible to early intervention before the consolidation of patterns of avoidance or academic dropout.

The analysis of sociodemographic associations showed that gender is significantly related to belonging to math anxiety profiles, while age at entry did not show a differentiating role. This finding is consistent with studies that indicate that differences in math anxiety in STEM contexts are structured more by gender than by age or previous academic background [17], [18], reinforcing the need to consider gender-sensitive approaches in the design of academic support strategies in engineering.

Beyond sociodemographic variables, the results showed that contextual variables play a key role in both latent profile membership and overall levels of math anxiety. Perceptions of mathematical performance, avoidance of mathematics-related activities, and mathematics anxiety reported since school age were consistently associated with higher anxiety profiles and higher total AMAS scores. These findings support models that conceptualize math anxiety as a phenomenon that is progressively constructed, integrating previous experiences, beliefs about personal competence, and current avoidance behaviors [7], [10], [27].

The mediation analysis provided additional evidence of this cumulative nature, showing that math anxiety experienced during school influences the avoidance of math activities in college both directly and indirectly, through current math anxiety. The presence of partial mediation suggests that early experiences not only leave a lasting emotional mark but also interact with the academic demands of first-year university, shaping coping patterns that can affect retention in highly math-intensive degree programs [9].

Finally, predictive models indicated that total math anxiety is the main determinant of belonging to latent profiles, above sociodemographic or contextual variables when these are considered together. This finding reinforces the usefulness of assessing math anxiety as a continuous and global construct to identify students at risk, especially in the early stages of university education [18], [23].

The results suggest that math anxiety in first-year engineering students should not be understood solely as a temporary reaction to the start of university life, but rather as a structured phenomenon that reflects previous emotional trajectories and current contextual conditions. In this sense, the accumulated evidence indicates that math anxiety is closely linked to psychosocial factors such as self-efficacy, sense of belonging, and academic motivation, which directly influence commitment and retention in STEM careers [23].

From an applied perspective, the findings of this study have direct implications for student retention in engineering programs, particularly during the first year of university, a critical stage characterized by high dropout rates. The identification of distinct profiles of math anxiety, together with evidence that overall anxiety and avoidance of math activities are closely linked to previous experiences and current perceptions of performance, suggests that math anxiety may operate as an early risk factor for vulnerable academic trajectories [7]. The predominantly evaluative anxiety pattern observed (assessment subscale $M = 3.34$ vs. learning subscale $M = 2.37$) points directly to the role of the institutional educational model: environments dominated by high-stakes examinations amplify anxiety in assessment contexts, while active learning and formative assessment approaches have been shown to reduce it [8], [25]. Future research should compare anxiety profiles across institutions with different pedagogical models to determine whether this pattern is specific to traditional models or holds across diverse educational contexts in the region.

Consequently, the systematic assessment of math anxiety at the beginning of the degree program could be a useful tool for the early detection of students at risk, allowing for the implementation of academic support programs, specialized tutoring, and psychoeducational strategies aimed at reducing avoidance and strengthening mathematical self-efficacy [25], [26]. Likewise, the results support the design of differentiated institutional policies based on the three identified profiles: (a) universal screening at enrollment using the AMAS, given the instrument's high reliability ($\alpha = 0.917$) and the demonstrated predictive value of total anxiety on profile membership ($R^2McF = 0.920$); (b) selective academic support for students classified in Profile 3 (moderate anxiety), targeting perceived performance deficits ($\beta = -0.493$) and avoidance behaviors ($\beta = 0.471$) through growth-mindset workshops and mathematics tutoring; and (c) indicated psychoeducational intervention for Profile 2 (high anxiety), addressing the strong influence of prior school anxiety ($\beta = 1.672$) through cognitive-behavioral strategies and mentoring programs that build mathematical self-efficacy from the first weeks of the academic term [10], [25], [26].

Among the main strengths of the study are the use of a real sample of first-year engineering students and the application of advanced analytical techniques, including latent profile analysis, multinomial regression, and mediation analysis, which made it possible to capture the heterogeneity of math anxiety and its contextual associations beyond traditional descriptive approaches [19]. Additionally, the absence of missing data and quality control in data collection strengthen the robustness of the results.

However, the study has limitations that should be considered when interpreting the findings. First, the cross-sectional design prevents establishing causal relationships between math anxiety and the contextual variables analyzed. Second, the use of self-reports may be subject to social desirability bias or subjective perception of performance. Finally, convenience sampling limits the generalization of the results to other educational contexts, so future research should consider longitudinal designs and multicenter samples to further explore the relationship between math anxiety, performance, and academic retention.

The identification of latent profiles and mediating mechanisms between early anxiety and avoidance of mathematical activities underscores the importance of addressing math anxiety not only as an individual problem but as an institutional challenge with implications for equity, performance, and student retention. In this sense, the results reinforce the need for evidence-based university strategies that promote early detection, timely intervention, and sustained academic support in engineering programs.

CONCLUSIONS

This study showed that math anxiety among first-year engineering students is a heterogeneous phenomenon, with moderate levels on average and greater activation in academic assessment contexts. The identification of three latent profiles of math anxiety made it possible to distinguish different patterns of anxious experience, going beyond approaches based solely on averages and highlighting the presence of an intermediate profile with preventive relevance.

The results showed that math anxiety is closely linked to contextual variables, particularly anxiety experienced since school, perception of math performance, and avoidance behaviors. Likewise, total math anxiety emerged as the main predictor of belonging to profiles of higher anxiety, reinforcing its usefulness as an early indicator of academic risk.

Taken together, these findings support the incorporation of early assessment of math anxiety into institutional strategies for academic support and guidance, with the aim of strengthening student adaptation and retention in engineering programs from the early stages of their university education. Furthermore, the three non-cognitive variables identified as significant predictors—prior school anxiety, perceived mathematical performance, and avoidance of mathematical activities—constitute a viable basis for an autonomous early warning system that engineering schools and faculties can implement at admission. By collecting these variables through a brief online questionnaire and applying the regression model derived in this study, institutions can automatically flag students at high risk before academic difficulties materialize, enabling proactive allocation of support resources. In addition, the profile structure and contextual data obtained provide specific guidelines for mathematics instructors: when high levels of evaluative anxiety are detected in a student, it is recommended to reduce the weight of single high-stakes exams, incorporate low-stakes formative assessments throughout the course, use collaborative problem-solving activities that normalize mathematical errors, and provide metacognitive coaching strategies to help students manage intrusive thoughts during evaluation. These classroom-level adjustments, grounded in the evidence from this study, complement broader institutional policies and directly respond to the needs of students in Profile 2 and Profile 3.

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