RESEARCH PAPER

Psychosocial Predictors of Dropout in Higher Education Exact Sciences: The Role of Math Anxiety and Academic Resilience

Carlos Fernando Moya López[1*], Omar Sebastián Muñoz Merino[2], Paula Camila Ramírez Mejía[3], Alex Fabián Uzhca Cayo[4]

[1] Psicólogo Educativo y Orientador Vocacional; Magister En Diseño Curricular y Evaluación Educativa Documento de Identidad: 1804076071*
ORCID del autor: https://orcid.org/0000-0002-1029-1484
Institución o universidad a la que está afiliada el autor: Universidad Intercultural de las Nacionalidades y Pueblos Indígenas Amawtay WasiCorreo electrónico institucional: carlos.moya@uaw.edu.ec
[2]Biofísico; Maestría En Physics País de procedencia del autor: Ecuador Documento de Identidad: 0604694315
ORCID del autor: https://orcid.org/0009-0002-0933-4966 Institución o universidad a la que está afiliada el autor: Escuela Superior Politécnica de Chimborazo Correo electrónico institucional: omar.munoz@espoch.edu.ec
[3]Psicóloga Mención Clínico; Magister En Psicología Clínica País de procedencia del autor: Ecuador
ORCID del autor: https://orcid.org/0009-0005-3813-3727 Institución o universidad a la que está afiliada el autor: Independiente Correo electrónico institucional: camilarm@hotmail.es
[4]Ingeniero Automotriz; Magister En Educación De Bachillerato Con Mención En Pedagogía De La Matemática
ORCID del autor: https://orcid.org/0009-0003-9245-8042 Institución o universidad a la que está afiliada el autor: U.E The British SchoolCorreo electrónico institucional: alex.uzhca@britishriobamba.edu.ec

ABSTRACT
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INTRODUCTION

Dropout rates in higher education remain a critical concern for educational institutions and policymakers worldwide, representing a significant loss of potential human capital and economic resources (Tinto, 2017). This issue is particularly acute in Science, Technology, Engineering, and Mathematics (STEM) disciplines, where attrition rates consistently outpace those in the humanities and social sciences (Chen, 2013). Despite the growing demand for a workforce skilled in exact sciences, a substantial number of students who enter these rigorous programs fail to complete their degrees, often leaving during the first two years of study (Wertz et al., 2013). Consequently, understanding the mechanisms underlying student persistence in these fields has become a priority for educational research (Sithole et al., 2017).

Traditionally, prediction models for STEM retention have relied heavily on cognitive variables, such as high school GPA, standardized test scores, and prior mathematical knowledge (Westrick et al., 2015). However, recent evidence suggests that while cognitive ability is necessary for success, it is not sufficient to explain why capable students abandon their studies. As a result, researchers have shifted their focus toward non-cognitive and psychosocial factors that may act as determinants of academic survival (Fong et al., 2017). Among these factors, two constructs have emerged as particularly influential within the context of quantitative disciplines: math anxiety and academic resilience (Casuso et al., 2013).

Math anxiety, defined as a feeling of tension and apprehension that interferes with the manipulation of numbers and the solving of mathematical problems, is a prevalent barrier in exact sciences (Ashcraft, 2002). Neuroscientific and psychological studies indicate that math anxiety disrupts working memory resources, leading to poorer performance even in individuals with high underlying mathematical competence (Ramirez et al., 2018). In the context of higher education, higher levels of math anxiety are associated not only with lower grades but also with "avoidance behaviors," where students choose to drop out of STEM majors to escape the distress associated with quantitative coursework (Ahmed, 2018). Furthermore, this anxiety often negatively correlates with self-efficacy, creating a cycle of doubt and underperformance that precipitates withdrawal (Justicia et al., 2017).

Conversely, academic resilience offers a protective framework against the inherent challenges of STEM education. It refers to a student's capacity to overcome acute or chronic academic adversity and maintain high motivation and performance despite the presence of stressful events (Martin, 2013). In the demanding environment of exact sciences, where failure rates in introductory courses can be high, resilience

*Author for Correspondence: Carlos Fernando Moya López

distinguishes those who persist from those who quit (Cassidy, 2016a). Resilient students are more likely to adopt adaptive coping strategies, view difficulties as challenges rather than threats, and seek help when needed (Trigueros et al., 2020).

Current research on student retention has increasingly moved away from analyzing isolated variables toward multidimensional models that integrate cognitive and non-cognitive factors. While seminal meta-analyses by (Westrick et al., 2015) established that standardized test scores and high school GPAs remain robust predictors of initial university performance, recent studies suggest these metrics are insufficient for explaining persistence in demanding STEM environments. To address this limitation, contemporary investigations have pivoted to frameworks similar to those proposed by (Tinto, 2017), which emphasize that a student's decision to persist is deeply rooted in their social and academic integration. Building on this, recent literature has begun to explore how specific psychological traits interact with this integration process to predict dropout risks in exact sciences (Robbins et al., 2004).

Specifically regarding the emotional barriers to learning, a growing body of evidence identifies Math Anxiety (MA) as a critical predictor of attrition in quantitative fields. In a study closely resembling the current inquiry, Justicia et al. (2017) demonstrated that anxiety toward mathematics does not merely correlate with lower grades but acts as a significant psychological barrier that diminishes a student's intent to continue in their major. This finding is supported by longitudinal research indicating that students with high levels of MA are three times more likely to switch to non-quantitative majors during their first year, regardless of their actual mathematical ability (Ahmed et al., 2012). These studies suggest that the fear of mathematics functions as an avoidance mechanism, leading to voluntary withdrawal before academic dismissal occurs (Ashcraft & Moore, 2009).

The mechanism through which anxiety influences dropout has been further clarified by cognitive psychology research. Several investigations propose that math anxiety consumes working memory resources, creating a "cognitive overload" that hinders the processing of complex scientific concepts (Beilock y Maloney, 2015). Research conducted by Ramirez et al. (2013) in undergraduate physics courses found that students with high anxiety performed significantly worse on exams not due to a lack of knowledge, but due to the inability to retrieve information under stress. Similarly, Hembree (1990)observed that this anxiety-induced underperformance creates a feedback loop of failure and reduced self-efficacy, which is a direct precursor to the decision to drop out of exact science programs.

However, the literature also highlights that not all students with high anxiety drop out, pointing to the moderating role of Academic Resilience. Trigueros et al. (2020)provided crucial evidence in this area, showing that students with higher emotional intelligence and resilience levels are better equipped to manage test anxiety and academic stress. Their work suggests that resilience acts as a buffer, allowing students to frame academic challenges as opportunities for growth rather than insurmountable threats. This aligns with findings by Cassidy (2016), who reported that resilient students in engineering programs maintained high engagement levels even after failing introductory calculus courses, whereas non-resilient peers tended to withdraw immediately.

The interaction between these two variables anxiety and resilience has been the subject of recent complex modeling in educational psychology. Studies by Martin y Marsh (2009) have explored the "protective factor" hypothesis, finding that resilience can neutralize the negative effects of math anxiety on academic performance up to a certain threshold. Furthermore, Putwain y Daly (2013) utilized structural equation modeling to show that while anxiety negatively predicts persistence, resilience positively predicts it directly and indirectly by reducing the perceived magnitude of academic stressors. This body of work underscores the necessity of analyzing these constructs jointly rather than in isolation [10].

While the individual impacts of math anxiety and resilience are well-documented, there is a need to understand how these variables interact within the specific population of exact science students. Recent literature suggests that resilience may mediate or moderate the negative effects of anxiety, acting as a buffer that allows anxious students to remain in their programs (Madigan, 2019). However, comprehensive models integrating these specific psychosocial predictors to forecast dropout risk in university-level science programs remain under-researched (Meneses et al., 2024). The present study aims to bridge this gap by analyzing the joint role of math anxiety and academic resilience in predicting dropout intentions among higher education students in exact sciences.

METHODOLOGY

This study was conducted using a quantitative, correlational-predictive approach and a non-experimental, cross-sectional design. This methodology was selected because the central objective is to examine the explanatory power of math anxiety and academic resilience on dropout intention, observing the phenomenon in its natural context without deliberate manipulation of variables. The cross-sectional design allowed for data collection at a single point in time, facilitating the analysis of structural relationships between risk and protective factors within the dynamics of university education.

The final sample consisted of 456 university students (M = 20.4 years; SD = 2.1) from the Faculty of Exact Sciences and Engineering at a public state university. The gender distribution was 58.3% male and 41.7% female. Participants enrolled in critical first-semester courses (Differential Calculus, Linear Algebra, and

Mechanics) were selected using purposive non-probability sampling. The distribution by major included Civil Engineering (30%), Systems Engineering (25%), Applied Mathematics (15%), and Physics (30%). As an inclusion criterion, students were required to be actively enrolled in at least one course with a required mathematics component.

A battery of psychometrically validated instruments was used for data collection. Math anxiety was assessed using the Abbreviated Math Anxiety Scale (AMAS) by Hopko et al. (2003), composed of 9 Likert-type items (α = .88), which measures anxiety related to learning and assessment in mathematics. Resilience was assessed using the Academic Resilience Scale (ARS-30) by Cassidy (2016), which consists of 30 items and evaluates adaptive responses to academic adversity, demonstrating high internal consistency in this study (α = .92). Finally, the dependent variable was measured using the Dropout Intention Scale, adapted from previous persistence models, composed of 5 items that explore the probability of dropping out of the program in the next semester (α = .85).

The instruments were administered digitally via the Google Forms platform during the mid-semester academic period, ensuring anonymity and obtaining informed consent from all participants. The data were initially processed using SPSS version 26.0 for descriptive and Pearson correlation analyses. Subsequently, to test the predictive hypotheses, a Structural Equation Model (SEM) was run using AMOS version 26.0. This multivariate analysis allowed for the simultaneous estimation of the direct effect of anxiety on dropout intention and the moderating role of academic resilience, evaluating the model fit using the CFI, TLI, and RM**1.**

RESULTS

Descriptive Analysis of the Variables

Table 1.*Descriptive Statistics and Normality Test for the Study Variables (N=456)*

Variable	Media (M)	OF	Min	Max	Asymmetry	Kurtosis	Cronbach's alpha
Mathematical Anxiety (AMAS)	28.42	5.61	9	45	0.34	-0.45	.88
Academic Resilience (ARS-30)	115.20	12.45	30	150	-0.21	0.18	.92
Intention to Desert	2.81	1.13	1	5	0.89	0.56	.85

Analysis:

As shown in Table 1, students reported levels of math anxiety above the theoretical midpoint, suggesting considerable stress related to mathematics in the sample. Academic resilience, on the other hand, showed a high mean (M=115.20), indicating a general self-perception of ability to cope with difficulties. Skewness and kurtosis values were within the acceptable range of ±1.5, confirming the univariate normality of the distribution and allowing the use of parametric tests. Furthermore, all instruments showed high internal consistency ($\alpha > .80$), ensuring the reliability of the measurements.

Correlation Matrix

Table 2.*Pearson correlations between anxiety, resilience, and dropout*

Variable	1	2	3
1. Math Anxiety	—		
2. Academic Resilience	-.35**	—	
3. Intention to Drop Out	.48***	-.52***	—

*Note: ** p < .01; ***p < .001*

Analysis:

Table 2 reveals statistically significant association patterns among all variables. A moderate-to-strong positive correlation ($r = .48$) stands out between Math Anxiety and Dropout Intention; this empirically confirms that greater anxiety is associated with a greater desire to abandon the program. In contrast, a strong inverse relationship ($r = -.52$) is evident between Resilience and Dropout, validating the protective function of resilience: more resilient students report a lower dropout intention. Finally, a negative relationship exists between anxiety and resilience ($r = -.35$), suggesting that high levels of math stress are often accompanied by fewer resilient coping resources.

Structural Equation Model (Prediction)

To evaluate the predictive weight of the independent variables on the dependent variable, a structural model was fitted. The fit indices were satisfactory: $x^2/gl = 2.45$; $CFI = .96$;$RMSEA = .054$.

Table 3.*Estimation of Standardized Coefficients (SEM Model)*

Trajectory (Route)	Standardized Coefficient(β)	Standard Error (SE)	Critical Ratio (CR)	Significance(p)
Math Anxiety → Dropout	.32	.04	4.12	< .001
Academic Resilience → Dropout	-.45	.05	-5.89	< .001
Explained Variance (R^2)	**.41**			

Analysis:
The results of the structural model presented in Table 3 confirm the study hypotheses. Academic Resilience ($\beta = -.45$) has a stronger negative predictive effect than Math Anxiety ($\beta = .32$). This implies that, although anxiety is a clear risk factor that pushes students toward dropping out, a lack of resilience is an even more critical predictor of dropout. Overall, the model achieves a coefficient $R^2$of .41, meaning that 41% of the variance in dropout intentions among science students can be explained by the interaction of these two psychosocial variables.

DISCUSSION

This study aimed to determine the predictive power of math anxiety and academic resilience on dropout intention among science students. The findings confirm the central hypothesis of the research: psychosocial variables play a determining role in student retention. Specifically, the validated structural model explained 41% of the variance $R^2 = .41$in dropout intention, a substantial percentage that suggests that success in STEM careers does not depend exclusively on cognitive abilities or prior performance (as suggested by classic models of Westrick et al.), but is strongly mediated by the student's emotional well-being and coping capacity in the face of academic pressure.

Regarding the risk variable, the results showed that Math Anxiety is a positive and significant predictor of dropout $\beta = .32$. This finding is consistent with that reported by Wertz et al. (2013) and Ashcraft and Moore (2009) , who postulate that anxiety acts as a cognitive barrier that not only affects immediate performance by blocking working memory, but also activates avoidance mechanisms. In the context of the exact sciences, where mathematics is the fundamental language of the curriculum, a high level of anxiety is not perceived as a passing difficulty, but as an insurmountable incompatibility with the degree program, which accelerates the decision to drop out before formal academic expulsion occurs.

However, the most revealing finding of this study is the prominent role of Academic Resilience, which proved to be the most robust predictor in the model ($\beta = -.45$), surpassing anxiety in statistical weight. This aligns with the research of Trigueros et al. (2020) and Cassidy (2016) , suggesting that the presence of stressors (such as mathematical difficulty) is less decisive than the student's ability to manage them. The data indicate that students with high resilience manage to "cushion" the negative impact of anxiety; that is, even when they experience stress, they possess adaptive resources that allow them to reinterpret failure or difficulty as temporary challenges rather than definitive threats to their academic identity.

From an educational perspective, these results have profound practical implications for higher education institutions. If almost half of the variance in dropout rates is explained by psychosocial factors, traditional retention strategies focused solely on academic leveling or calculus tutoring are insufficient. As Tinto (2017) pointed out , academic integration also requires emotional support. Faculties of exact sciences should consider implementing socio-emotional skills development programs from the first year, focusing on anxiety reduction techniques and resilience building, transforming the culture of academic "filtering" into one of comprehensive support.

It is necessary to acknowledge certain limitations of the study. The cross-sectional design prevents establishing strict causal relationships over time; we do not know whether low resilience causes dropout or whether prior academic failure diminished the student's resilience. Future research should adopt longitudinal designs to track how these constructs evolve from admission to graduation. Likewise, it would be valuable to include objective performance variables (grade point average) to analyze how they interact with psychological self-perception in more complex mediation models. Despite this, current evidence is compelling in indicating that strengthening "psychological muscle" is as vital as training logical reasoning to ensure success in the exact sciences.

CONCLUSIONS

First, it is concluded that the proposed predictive model has high empirical validity for explaining the phenomenon of dropout in science programs. The results demonstrated that the interaction between math anxiety and academic resilience explains 41% of the variance in dropout intention. This allows us to affirm that the decision to drop out is not an event driven solely by cognitive deficiencies or a lack of prior knowledge, but rather is the result of a complex psychological process where the perception of threat (anxiety) and coping skills (resilience) play a role as crucial as academic performance itself.

Specifically, academic resilience was identified as the most critical factor in the retention equation, statistically outweighing math anxiety. While fear of mathematics acts as a catalyst that pushes students toward dropping out, resilience functions as a robust protective shield. This implies that a student with high anxiety will not necessarily drop out if they possess sufficient resilience to manage that stress; conversely, a lack of resilience, combined with the demands of the exact sciences, creates the highest risk scenario for university disengagement.

From an institutional perspective, these findings necessitate a rethinking of current retention strategies in engineering

and science faculties. It is concluded that interventions focused solely on academic leveling (such as calculus or physics tutoring) are insufficient without accompanying socio-emotional support. It is imperative to integrate curricular or extracurricular programs that explicitly foster the development of resilience and emotional regulation from the first semester, transforming the educational culture from a "natural selection" approach to one of holistic student development.

This study provides strong evidence for considering mental health as a strategic educational variable. It establishes that success in STEM disciplines requires a balance between technical competence and psychological resilience. Future research should address, using longitudinal designs, the effectiveness of specific psychological interventions in these populations to confirm whether resilience training can effectively reduce dropout rates throughout their academic careers.

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