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PAPER

Explanatory Model on Academic Self-Efficacy in Engineering Students: Role of Anxiety, Dysthymia, and Negative Affect

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ABSTRACT

Students in engineering tend to be loners, making interpersonal relationships and mental health issues more likely to arise. The COVID pandemic caused university students to experience anxiety and depression, which affected their academic performance and self-esteem. However, students' mental health was rarely evaluated after the pandemic, especially engineering students, who showed higher levels of depression than students from other disciplines. The present study aims to establish an explanatory model of academic self-efficacy based on factors related to mental health, such as anxiety, depression, and negative emotions. The method used was quantitative cross-sectional, and a structural equation modeling was used. A sample of 561 students (54.4% males and 45.6% females) was analyzed. Instruments to measure self-efficacy, negative affect, depression, and anxiety, previously validated and with adequate reliability, were applied. The results showed that a state of anxiety affects academic self-efficacy negatively and directly; depression and negative affect indirectly affect academic self-efficacy mediated by a state of anxiety. These results show that a student with depression problems and a predominance of negative emotions is vulnerable to present anxiety in an academic setting. This anxiety causes his efficacy beliefs to decrease. As a result, he does not feel capable of facing academic challenges.

KEYWORDS

self-efficacy, anxiety, depression, emotions, structural equation modeling (SEM)

1 INTRODUCTION

The COVID-19 pandemic presented significant challenges for universities in Latin American countries. In response, many universities rapidly transitioned to remote learning, significantly shifting educational practices and knowledge acquisition [1]. Reports indicate that university students in Latin America experienced increased rates of depression, anxiety, and stress [2], [3], and this impacted their sleep patterns

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during the pandemic [4]. These findings highlight the impact of the pandemic on students' mental health, which may have been exacerbated by quarantine and social isolation measures. At the beginning of the 2020-21 academic year, more than 80% of college students expressed distress related to the uncertainty of the educational environment. Moreover, 67% students believe that the ongoing coronavirus pandemic has resulted in an inability to plan for their future [5]. While universities have since shifted to a hybrid system, the challenges associated with this new adaptive process have yet to be fully studied [6]–[8]. Thus, it is crucial to continue monitoring and researching the effects of the pandemic on university students in Latin America.

On the other hand, engineering students often prefer to work independently and in solitude compared with students in other majors [9], [10]. Consequently, engineering students tend to have poorer socialization levels than their peers in other disciplines [11]. Low levels of socialization can have a direct impact on emotional and cognitive stability. It is important to note that while solitary behavior may have helped engineering students cope with social confinement during the pandemic, the post-pandemic return to face-to-face education presents a new set of challenges. Thus, it is crucial to continue exploring the impact of socialization on engineering students' academic performance and mental health in remote and face-to-face learning environments.

The COVID-19 pandemic has significantly impacted the mental health of engineering students, who have reported higher levels of depression, anxiety, and stress than medical students [12]. In addition, factors contributing to positive and negative mental health outcomes are closely related to an individual's beliefs about their ability to succeed (i.e., efficacy beliefs) [13]. Therefore, it is crucial to investigate the factors that may decrease academic self-efficacy, especially among engineering students, who are typically independent and may experience feelings of loneliness. To achieve this, studies are needed to examine the mental health factors affecting engineering students' self-perception of efficacy in the post-pandemic context.

1.1 Research model

Self-efficacy refers to a person's belief in their abilities to accomplish specific tasks or achieve certain goals [14]. This psychological phenomenon is crucial in guiding behavior and promoting success [15]. Self-efficacy is a complex construct that encompasses cognitive, emotional, and motivational factors [16]–[18], and it facilitates the regulation of behavior toward the attainment of goals [19], [20]. Studies have shown that poor self-efficacy is associated with academic failure among students [21]. Given the constant academic challenges and increasing demands college students face, developing self-efficacy is critical for their success in academic endeavors.

Self-efficacy has been studied with other psychological factors, including self-esteem, grit, academic self-regulation, motivation, satisfaction, psychological well-being, achievement expectations, positive stress, and academic success [22]–[24]. While self-efficacy is often associated with positive outcomes, it is also linked to negative factors, such as procrastination, negative stress, negative emotions, anxiety, and depression [25], [26]. This raises the question of whether mental health factors directly impact academic self-efficacy. Some studies have provided evidence of this association [13], [27], but their focus has not been on educational settings, and further research is necessary to examine their replicability among students.

Anxiety and depression are among the mental health factors that have been reported to increase during the pandemic [28], highlighting the need to study them in the post-pandemic context. Therefore, the need to study them in the post-pandemic

context has become relevant. Furthermore, anxiety and depression negatively impact interpersonal relationships, family, and emotional bonds, leading to self-criticism [29], [30]. Anxiety can also impair daily functioning and performance, but research suggests that learning to manage anxiety can help students develop new behavioral and emotional self-control competencies [31], [32], enhancing their capabilities. However, anxiety has been found to have a negative effect on academic self-efficacy [34]. When a student experiences anxiety, they may experience self-doubt and create a stressful environment that can impede their academic performance. Depression is also known to hinder academic performance, and several studies have investigated its association with academic self-efficacy [33], finding a negative effect where high levels of depression decrease self-efficacy.

A structural equation modeling (SEM) model must be used to develop an explanatory model based on the variables of interest. SEM is a powerful statistical technique that allows researchers to evaluate complex relationships among multiple variables. It has become increasingly popular in social science research, including psychology, sociology, and education. This technique enables researchers to develop and test theoretical models, including observed and unobserved variables [34]. However, before using SEM in a study, it is essential to assess the validity and reliability of the model.

Validity refers to the extent to which the model accurately measures what it intends to measure. In the case of SEM, the model should accurately reflect the theoretical relationships between the variables of interest. The validity of SEM models can be assessed using several methods, including confirmatory factor analysis, goodness-of-fit tests, convergent and discriminant validity, and comparison of alternative models [35]. *Reliability* refers to the consistency of the measurements [36]. In SEM, reliability can be assessed by estimating the internal consistency of the observed and latent variables. Additionally, assessing the stability of the model over time and across different samples can help determine its reliability.

Based on the explanation above, the following hypotheses were formulated:

- H1: State anxiety has a direct and negative effect on self-efficacy.
- H2: Dysthymia has a direct effect on state anxiety.
- H3: Negative affect has a direct effect on state anxiety.
- H4: Dysthymia has an indirect effect on self-efficacy through state anxiety.
- H5: Negative affect has an indirect effect on self-efficacy through state anxiety.

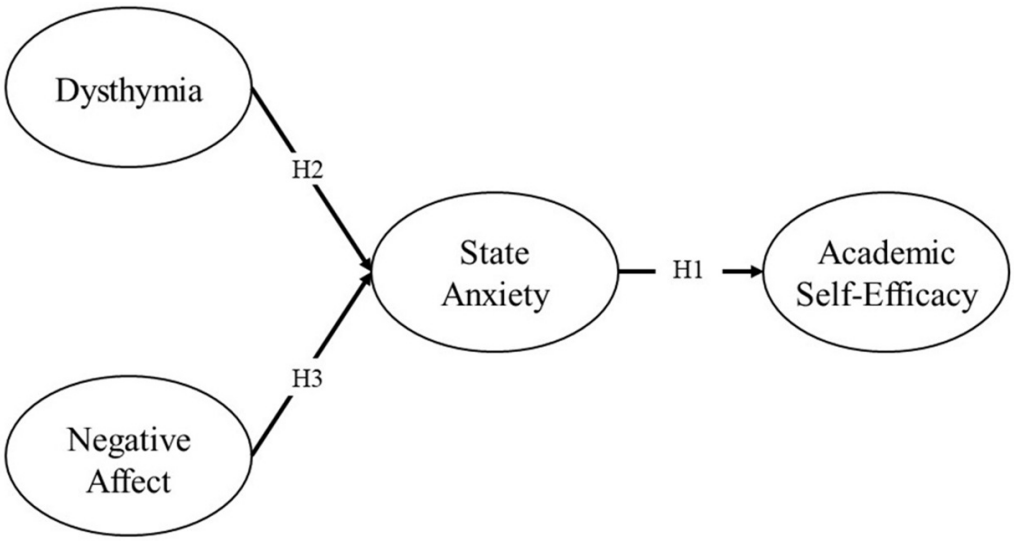

Fig. 1. Hypothesized research model

2 MATERIALS AND METHODS

2.1 Sample

The data were obtained through nonprobabilistic convenience sampling. The participants were 561 students of industrial engineering (36.9%), economic engineering (48.5%), and systems engineering (14.6%). The mean age of the participants was 23 years (SD = 4.89 years, range = 18–50 years). A total of 75.4% of those evaluated were single, 20.9% married, 2.7% divorced, 0.5% widowed, and 0.5% did not report their marital status. Also, 49.4% reported that they studied full-time, 8.7% worked part-time, 31.6% worked full-time, 9.4% were self-employed, and 0.9% did not report.

2.2 Instruments

The information collection was done through the survey technique. We used four instruments to measure the established variables.

The study used four different instruments to measure different psychological factors in the students. The first instrument was the Academic Situations Specific Perceived Self-Efficacy Scale (EAPESA) [37], which had nine items that students answered on a five-point scale. It was found to have good reliability and psychometric properties, meaning it is a useful tool for measuring perceived self-efficacy in university students. In its last psychometric review, the instrument had a unidimensional structure [38], where indices of its factorial structure (CFI = 0.99; TLI = 0.99; RMSEA = 0.07; SRMR = 0.03) and reliability (α = 0.91; ω = 0.91) were adequate.

The second instrument used was the State Anxiety Subscale of the State-Trait Anxiety Questionnaire (STAI), which had six items that students answered on a five-point scale. This instrument was found to be reliable for measuring state anxiety in adult populations (λ_4 = 0.86) and had a single construct, making it easy to interpret.

The third instrument was the Scale of Positive and Negative Experience (SPANE) [39], which assesses positive and negative affect through twelve items. Cassaretto and Martínez-Uribe [40] validated the instrument, and they obtained adequate reliability for positive affect (α = 0.91) and negative affect (α = 0.87). This shows that SPANE has demonstrated reliability in samples of university students.

Finally, the Trait State Depression Inventory instrument, validated by Dominguez-Lara [41], was used to assess dysthymia. TSDI consists of twenty items: ten for dysthymia and ten for euthymia. The instrument obtained Aiken's V value above 0.80, and an exploratory factor analysis was performed with a two-factor solution. The reliability was adequate (> 0.70).

2.3 Procedure

In order to be able to apply the instrument, first, the project's approval was obtained through the Ethics Committee of the University Sciences and Humanities (CEI Act N° 029; Cod.: 043-22). Then, a virtual form was prepared with informed consent and the previously specified instruments. The distribution of the form took place between November and December 2022. Participants had 15 minutes to answer the form. The support of university teachers was used to distribute the form. Finally, all the evaluated gave their informed consent to participate in the study.

2.4 Analysis technique

The R Studio environment (v. 4.2.2.) was used for the analysis. First, descriptive statistics were evaluated, ensuring that the items of each latent factor presented univariate normality; for this, the criterion of skewness (±2) and kurtosis (±8) was used [42]. Subsequently, the correlation matrix between latent factors was evaluated through Cohen's criterion [43], in which a relationship is weak (0.10), medium (0.30), or strong (0.50). Discriminant validity was analyzed using the Heterotrait-Monotrait criterion [44], which must be less than 0.85 to ensure independence between latent variables.

For the structural equation model, the items were a Likert-type scale; however, they were considered continuous [45]. For SEM, we used The Robust Maximum Likelihood estimator [46]. The following fit indices were evaluated: chi-square (χ^2), degrees of freedom (gl), comparative fit index (CFI), Tucker Lewis index (TLI), and root mean square error of approximation (RMSEA) with confidence intervals (CI 90%) [47]. The following criteria were considered to evaluate the fit indices: >.90 (CFI, TLI); <.08 (RMSEA; CI 90%). In addition, the coefficient of determination (R^2; Cohen, 1988) was analyzed. Small (0.02), medium (0.15), and long (0.35) size criteria were used. Confidence intervals were calculated at 95% using the bootstrapping procedure with 5000 resamples [48]. Therefore, the standardized (β) and unstandardized (β) estimators and their confidence intervals obtained through the bootstrapping technique with 5000 resamplings will be presented when describing the results.

3 RESULTS

The items for each variable were first analyzed (Table 1), and it was found that their skewness and kurtosis were adequately distributed (within ±2 and ±8, respectively). The reliability of the latent variables was assessed using alpha (α) and omega (ω) coefficients, which were both greater than 0.70, and composite reliability (CR), which was greater than 0.60 [49]. Next, the correlation matrix between latent variables was calculated, and coefficients between 0.41 and 0.73 were obtained. Coefficients below 0.80 indicate independence between variables. Discriminant validity was also assessed using the Heterotrait-Monotrait criterion [44], and the results demonstrated independence between the variables with coefficients lower than 0.85.

Table 1. Reliability, matrix correlation, and discriminant validity

	Reliability			Matrix Correlation and Discriminant Validity			
	CR	α	Ω	1	2	3	4
1. Academic self-efficacy	0.90	0.90	0.90	–	*–0.54*	*–0.41*	*–0.43*
2. State anxiety	0.75	0.74	0.74	–0.56	–	*0.72*	*0.68*
3. Dysthymia	0.91	0.91	0.91	–0.42	0.73	–	*0.70*
4. Negative affect	0.80	0.79	0.79	–0.41	0.66	0.70	–

Note: Italics indicates discriminant validity (HTMT criterion).

The hypothesized model (Figure 1) was tested, and adequate fit indices were obtained, with each index evaluated using different criteria as displayed (Table 2). The absolute measures were found to be marginally acceptable, while the incremental fit and parsimony measures indicated the marginal acceptability of the model. These findings demonstrate that the model has an excellent empirical fit for evaluation.

Table 2. Summary of the goodness-of-fit indices

The Goodness-of-Fit Measure	Index Value	Cut-Off Value
Absolute-fit measures		
Chi-square (χ^2)	560.691	N/A
Degrees of freedom (df)	295	N/A
Significance level (p-value)	0.000	≥ 0.05
Goodness-of-fit index (GFI)	0.912	≥ 0.90
Root mean-square residual (RMR)	0.047	≤ 0.08
Standarized root mean-square residual (SRMR)	0.043	≤ 0.08
Root mean-square error of approximation (RMSEA)	0.040	≤ 0.08
RMSEA CI 90% lower	0.036	≤ 0.08
RMSEA CI 90% upper	0.045	≤ 0.08
Incremental-fit measure		
Comparative fit index (CFI)	0.949	≥ 0.90
Tucker-Lewis index (TLI)	0.943	≥ 0.90
Parsimonious-fit measure		
Normed chi-square (χ^2/df)	1.90	1.00–2.00

The hypothesized model was analyzed using both Figure 2 and Table 3. The latter presents the standardized regression coefficients and statistical significance, the unstandardized regression coefficient, and its confidence interval obtained by bootstrapping (N = 5000), while the former illustrates the model with latent variables. Results confirmed the direct-effects hypotheses. When testing H1, it was found that the direct and negative effect of state anxiety toward academic self-efficacy is significant and robust (β = –0.57, p < 0.001; β = –0.64, CI 95%: –0.79, –0.51); similarly, it was found that the model explains 32% of the variance of self-efficacy. For H2, a direct and positive effect of dysthymia on state anxiety was also found (β = 0.52, p < 0.001; β = 0.36, 95% CI: 0.24, 0.49). Likewise, H3 was tested, and negative affect was found to have a direct, positive effect on state anxiety (β = 0.31, p < 0.001; β = 0.27, 95% CI: 0.10, 0.44). Both dysthymia and negative affect explained 59% of the variance in state anxiety. These results demonstrate the veracity of the direct-effects hypotheses.

Concerning indirect effects (Table 3), H4 showed that dysthymia has an indirect and negative effect on academic self-efficacy through state anxiety (β = –0.30, p < 0.001; β = –0.23, 95% CI: –0.33, –0.15). Similarly, H5 posited an indirect effect of negative affect on academic self-efficacy through state anxiety that was negative and significant (β = –0.17, p < 0.001; β = –0.17, 95% CI: –0.29, –0.07). Finally, these results support the indirect effects of the model.

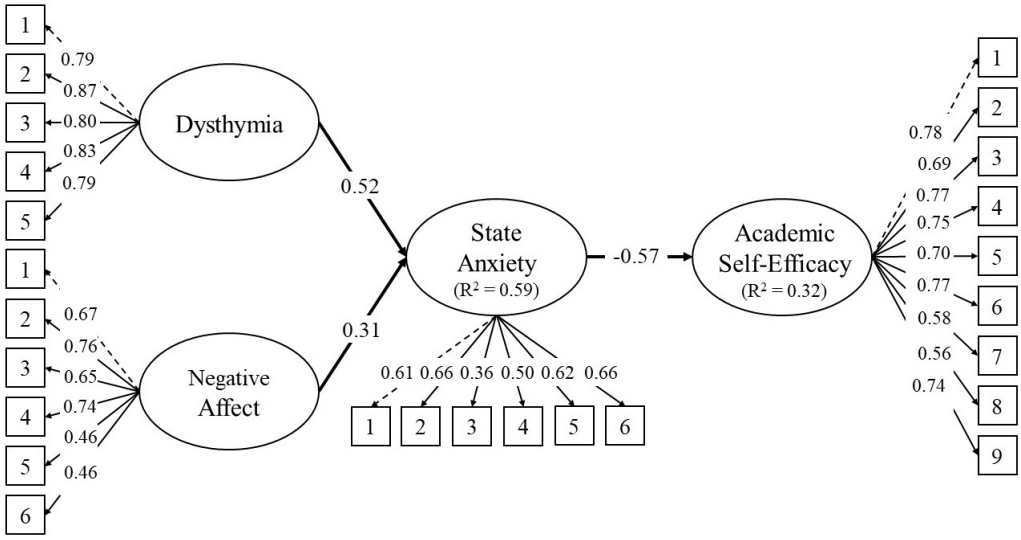

Fig. 2. Research model regression coefficients

Table 3. Summary of hypotheses testing

Effects	*β*	p-Value	β	β CI 95%	
				Lower	Upper
Direct effects					
S. Anxiety → A. Self-efficacy (a)	–0.57	0.000	–0.64	–0.79	–0.51
Dysthymia → S. Anxiety (b)	0.52	0.000	0.36	0.24	0.49
Negative affect → S. Anxiety (c)	0.31	0.001	0.27	0.10	0.44
Indirect effects					
Dysthymia → S. Anxiety → A. Self-efficacy	–0.30	0.000	–0.23	–0.33	–0.15
Negative affect → S. Anxiety → A. Self-efficacy	–0.17	0.002	–0.17	–0.29	–0.07

4 DISCUSSION

This research aims to establish a model that examines the effect of dysthymia (depression) and negative affect on anxiety as a state, and to evaluate the extent to which anxiety influences self-perception of efficacy in a post-pandemic context. Over the past few years, education has undergone significant changes, and students have had to adapt and establish new habits in response. In the post-pandemic era, mental health professionals are evaluating the extent to which depressive and anxious symptoms affect individuals' current quality of life. However, depression and anxiety remain major factors affecting student performance in the educational context [33], [50]. Therefore, it was critical to investigate the impact of depression and anxiety on students' academic performance and mental health in the post-pandemic context.

Self-efficacy is a psychological factor related to success [15] and good academic performance. Difficulties that may affect its stability will negatively influence the student's ability to achieve his or her goals. Self-efficacy beliefs are motivational, so students with high self-efficacy can be constantly active in their personal and

professional development [16]–[18]. However, research suggests that state anxiety can negatively influence self-efficacy, which arises in response to specific situations. Anxiety can also impact students' performance and self-esteem, leading them to question their abilities [51]. For example, engineering students may experience anxiety when facing complex tasks or exams, which can undermine their self-efficacy and impair their exam performance.

Not only is anxiety an adequate negative predictor of self-efficacy [52]. Our findings suggest that dysthymia indirectly affects self-efficacy, with anxiety as a mediator between the two. Consistent with prior research, persistent depression or dysthymia has been identified as a salient psychological phenomenon that restricts one's capabilities and interferes with daily functioning [53]. Dysthymia is both a direct predictor of state anxiety and an indirect predictor of academic self-efficacy, as established in earlier studies [54], [55]. Students exhibiting symptoms of depression and anxiety may encounter difficulties maintaining stable levels of self-efficacy, which could negatively impact their academic performance. Consequently, they may experience disadvantages compared with those without anxiety and depression.

Similarly, negative affective states are crucial in understanding the perception of emotions such as sadness, fear, annoyance, and discomfort [39]. These states can significantly impair academic performance by generating general discomfort [56], overloading the student, and causing exhaustion [57]. Depression and anxiety can restrict students from achieving high grades and limit their learning potential. Our study demonstrates that negative affect indirectly influences self-efficacy through anxiety, which is consistent with the finding that emotions such as sadness and fear often co-occur with anxiety. Overall, our results suggest that negative affect and anxiety can both act as barriers to academic success and may need to be addressed to improve students' learning outcomes.

5 CONCLUSIONS

In summary, this study aimed to establish an explanatory self-efficacy model by proposing a set of direct and indirect effects involving dysthymia, negative affect, and state anxiety. The results support the proposed hypotheses, with 32% of the variance in academic self-efficacy explained by the model. Specifically, anxiety as a state variable was found to directly influence self-efficacy and mediate the effects of dysthymia and negative affect. The established model has theoretical and practical implications for educators, psychologists, and psychopedagogists. For instance, it can guide educational interventions to manage negative emotions such as sadness, fear, and anger to indirectly enhance self-efficacy by reducing depressive symptoms. Moreover, this model helps to elucidate the dynamics of academic self-efficacy when influenced by psychological factors such as anxious and depressive episodes.

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