

HOW STUDENTS FEEL AND BEHAVE IN STATISTICS: PREDICTING PROCRASTINATION AND PERFORMANCE

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Abstract

Statistics education plays a crucial role in the development of scientific literacy across diverse academic fields, yet many university students experience difficulties associated with low self-efficacy, anxiety, and negative attitudes towards statistics. These affective and motivational factors influence engagement, procrastination, and academic performance, forming a complex network of relationships that remains underexplored in integrated models. This study examined the effects of self-efficacy, statistics anxiety, attitudes towards statistics, engagement in statistics, procrastination, and perceived academic performance using a structural equation modelling approach (PLS-SEM).

A sample of 668 Portuguese university students completed a questionnaire comprising these six validated constructs and some sociodemographic variables. Of the twelve hypotheses tested, seven were supported—five direct effects and two indirect effects. Statistics anxiety had a strong positive impact on procrastination, while more favourable attitudes towards statistics significantly reduced anxiety and enhanced engagement and perceived academic performance. Procrastination negatively affected academic performance. Additionally, attitudes influenced performance indirectly through sequential mediation by anxiety and procrastination, and procrastination mediated the impact of anxiety on performance. These findings highlight the central role of attitudes, the detrimental effects of anxiety, and the behavioural consequences of procrastination in shaping students' learning outcomes. The study underscores the need for pedagogical strategies that foster positive attitudes, reduce anxiety, support engagement, and promote effective self-regulation in statistics education.

Keywords: Statistics anxiety, attitudes towards statistics, engagement, procrastination, academic performance, PLS-SEM, higher education.

1 INTRODUCTION

Statistics is a core component of higher education programmes in disciplines such as psychology, education, health sciences, and business. Despite its central role, many students approach statistics with apprehension, scepticism, and low confidence. These negative perceptions are frequently associated with reduced engagement, increased procrastination, and poorer academic outcomes. Consequently, understanding the psychological and contextual factors that shape university students' attitudes towards statistics and their engagement with the subject is critical, particularly given the potential direct and indirect effects on procrastination and academic performance.

In this context, self-efficacy, attitudes, anxiety, and engagement emerge as key constructs, with both direct and indirect influences on procrastination behaviours and perceived academic performance. Self-efficacy, as a central expectancy belief, plays a crucial role in shaping students' emotional responses, attitudes, effort, and persistence [1]. Within statistics education, higher levels of self-efficacy are consistently associated with lower anxiety, more positive attitudes, and stronger academic engagement [1].

Attitudes towards statistics — encompassing perceptions of relevance, interest, and value — are likewise fundamental in shaping students' motivation and openness to learning. Positive attitudes are linked to higher levels of engagement and may buffer the emotional strain associated with cognitively demanding coursework. Empirical evidence consistently indicates that students who believe in their capacity to learn and apply statistics tend to hold more favourable attitudes towards the subject [2–4].

Self-efficacy has been shown to reduce statistics-related anxiety while simultaneously enhancing positive attitudes and engagement [5–8]. Beyond its direct effects, self-efficacy may also function as a mediating mechanism, attenuating anxiety and promoting engagement, which in turn contribute to more positive attitudes towards statistics [2–3, 5].

Attitudes towards statistics influence the perceived value and meaning students assign to statistical knowledge. Positive attitudes foster emotional engagement and increase students' willingness to

engage with complex or uncertain content. Conversely, negative attitudes — particularly perceptions of irrelevance or excessive difficulty — are likely to intensify anxiety and undermine engagement [8].

Procrastination in statistics courses often emerges as a behavioural response to anxiety and low motivation. When students delay studying or completing assignments, they experience increased time pressure and fewer opportunities for practice, which can impair performance and reinforce negative self-beliefs. Perceived academic performance, although subjective, constitutes a meaningful indicator of students' confidence and self-evaluative judgements and is closely linked to their affective experience of the course.

Empirical studies indicate that anxiety and negative attitudes are positively associated with procrastination [3, 9–11]. In contrast, engagement and positive attitudes are associated with higher perceived academic performance, while procrastination is linked to poorer outcomes [12–14].

Against this theoretical and empirical backdrop, the present study examines the factors that shape attitudes and engagement in statistics and investigates how these factors contribute to procrastination and perceived academic performance. Extending prior research, we propose and test a set of hypotheses addressing the direct, indirect, and mediating relationships among self-efficacy, attitudes, anxiety, engagement, procrastination, and performance:

- H1: Self-efficacy has a significant effect on statistics anxiety.
- H2: Self-efficacy has a significant effect on attitudes towards statistics.
- H3: Self-efficacy has a significant effect on academic engagement in statistics.
- H4: Statistics anxiety has a significant effect on procrastination.
- H5: Attitudes towards statistics have a significant effect on statistics anxiety.
- H6: Attitudes towards statistics have a significant effect on academic engagement in statistics.
- H7: Attitudes towards statistics have a significant effect on perceived academic performance.
- H8: Attitudes towards statistics have a significant effect on procrastination.
- H9: Academic engagement in statistics has a significant effect on perceived academic performance.
- H10: Procrastination has a significant effect on perceived academic performance.
- H11: Statistics anxiety and procrastination mediate the relationship between attitudes towards statistics and perceived academic performance.
- H12: Procrastination mediates the relationship between statistics anxiety and perceived academic performance.

2 METHODOLOGY

Data collection was conducted between 15 January and 31 May 2025. The inclusion criterion required participants to be university students from a wide range of academic disciplines who had completed at least one statistics course as part of their programme.

A questionnaire was used which, in addition to sociodemographic variables, included 77 items divided into six constructs [Self-efficacy in Statistics (SES) [15], Anxiety in Statistics Examination (ASE) [16], Attitudes towards Statistics (ATTS) [17], Engagement in Statistics (ES) [18], Procrastination (P) [19], and Perceived Academic Performance (PAP) [20]]. All 62 items across the first four constructs under analysis (SES, ASE, ATTS, and ES) were self-report measures assessed using a five-point Likert scale ranging from 1 (Strongly Disagree; SD) to 5 (Strongly Agree; SA). In addition, the 15 items corresponding to the constructs P and PAP were assessed using a five-point Likert scale ranging from 1 (Never; N) to 5 (Always; A).

Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM), implemented in SmartPLS 4. The minimum required sample size was determined based on the guidelines proposed by Soper [21], which consider the number of latent variables, anticipated effect sizes, and statistical power requirements. Given 77 indicators, six latent constructs, an expected effect size of 0.16, a statistical power of 0.80, and a significance level of 0.05, the minimum sample size required to detect effects was 648 cases. The final dataset comprised 668 valid responses, exceeding the methodological requirement and providing a high level of statistical reliability for a model of this complexity.

The model's explanatory power was evaluated using the coefficient of determination (R^2), a central metric in PLS-SEM (see Figure 1). Procrastination achieved an R^2 value of 0.998, indicating that 99.8% of its variance is jointly explained by statistics anxiety and attitudes towards statistics. Engagement in statistics yielded an R^2 value of 0.729, primarily driven by self-efficacy in statistics and attitudes towards

statistics. Perceived academic performance recorded an R^2 value of 0.275, reflecting the combined effects of attitudes towards statistics, engagement in statistics, and procrastination. Taken together, these results indicate that the proposed model shows strong explanatory and predictive capability.

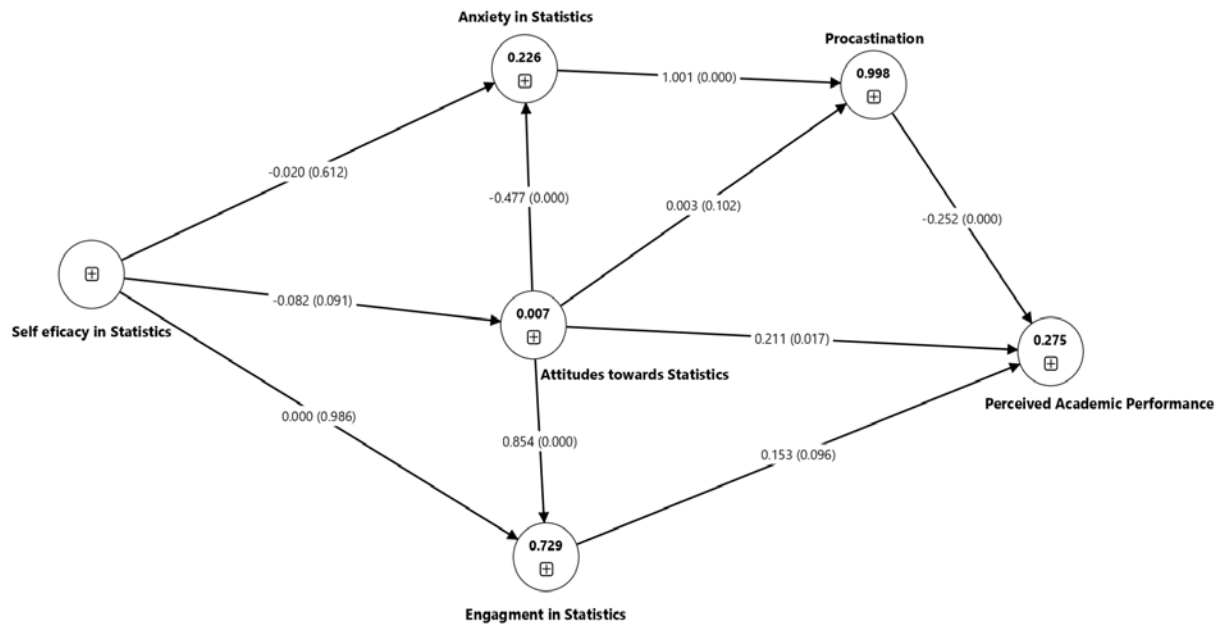


Figure 1. Structural model showing R^2 values for each endogenous construct

3 RESULTS

The reliability assessment showed that all reflective indicators exhibited factor loadings above 0.50, indicating a strong correspondence between the observed variables and their respective latent constructs. Table 1 summarises the results for Cronbach's alpha (CA), composite reliability (CR), and average variance extracted (AVE), alongside the thresholds adopted to evaluate the quality of the measurement model.

Cronbach's alpha values ranged from 0.856 to 0.985, exceeding the recommended minimum threshold of 0.60 [22] and indicating strong internal consistency across all constructs. Composite reliability values varied from 0.898 to 0.986, confirming a high degree of internal consistency and indicating that the indicators reliably capture the underlying dimensions of the model. Furthermore, AVE values were consistently above 0.50 for all constructs, meeting the criterion for convergent validity and indicating that more than half of the variance in the indicators is accounted for by their respective latent variables [22].

Taken together, these findings confirm that the measurement model meets the methodological standards required for high-quality PLS-SEM estimation, thereby ensuring the robustness and validity of the subsequent structural model analyses.

Table 1. Reliability and Discriminant Validity

| Constructs | CA | CR | AVE | Construct correlations* | | | | | |
|------------|-------|-------|-------|-------------------------|--------------|--------------|--------------|--------------|--------------|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1) SES | 0.920 | 0.936 | 0.746 | 0.864 | 0.027 | 0.079 | 0.065 | 0.026 | 0.042 |
| 2) ASE | 0.985 | 0.986 | 0.829 | 0.019 | 0.911 | 0.483 | 0.504 | 0.863 | 0.472 |
| 3) ATTS | 0.975 | 0.977 | 0.604 | -0.082 | -0.475 | 0.777 | 0.866 | 0.481 | 0.502 |
| 4) ES | 0.977 | 0.979 | 0.660 | -0.069 | -0.492 | 0.854 | 0.812 | 0.503 | 0.501 |
| 5) P | 0.977 | 0.981 | 0.838 | 0.018 | 0.929 | -0.472 | -0.489 | 0.915 | 0.470 |
| 6) PAP | 0.856 | 0.898 | 0.640 | -0.034 | 0.019 | 0.461 | 0.457 | 0.018 | 0.800 |

*Fornell-Larcker Criterion and Heterotrait-Monotrait Ratio (HTMT). Bold values represent the square root of the AVE; Fornell-Larcker values are shown below the diagonal, while HTMT ratios are shown above the diagonal.

According to Henseler et al. [23], HTMT values exceeding 0.90 may indicate inadequate discriminant validity and potential overlap between constructs. In the present study, all HTMT ratios remained well below this threshold, suggesting that each construct represents a distinct conceptual domain and that the variables are empirically separable, thereby providing evidence of satisfactory discriminant validity. Having established these psychometric properties, the constructs were subsequently incorporated into the structural model for hypothesis testing.

Bootstrapping procedures were employed to assess the significance and relevance of the path coefficients. Of the twelve hypotheses tested, seven were supported by the results (Table 2), including five direct effects and two indirect effects.

Table 2. Hypothesis Testing Results

| Hypothesis | Path Coefficient (β) | t-value | p-value | Supported |
|------------------------------|------------------------------|----------|---------|-----------|
| H1: SES -> ASE | -0.020 | 0.508 | 0.612 | No |
| H2: SES -> ATTS | -0.082 | 1.691 | 0.091 | No |
| H3: SES -> ES | 0.000 | 0.018 | 0.986 | No |
| H4: ASE -> P | 1.001 | 1104.054 | 0.000 | Yes |
| H5: ATTS -> ASE | -0.477 | 14.603 | 0.000 | Yes |
| H6: ATTS -> ES | 0.854 | 52.637 | 0.000 | Yes |
| H7: ATTS -> PAP | 0.211 | 2.392 | 0.017 | Yes |
| H8: ATTS -> P | 0.003 | 1.634 | 0.102 | No |
| H9: ES -> PAP | 0.153 | 1.663 | 0.096 | No |
| H10: P -> PAP | -0.252 | 5.162 | 0.000 | Yes |
| H11: ATTS -> ASE -> P -> PAP | 0.120 | 5.156 | 0.000 | Yes |
| H12: ASE -> P -> PAP | -0.252 | 5.164 | 0.000 | Yes |

In the present study, self-efficacy in statistics did not exert a statistically significant effect on statistics anxiety, attitudes towards statistics, or engagement in statistics. This finding diverges from the majority of recent empirical studies examining these relationships. Notably, only Dodeen and Alharballeh [9] similarly reported non-significant associations between self-efficacy and attitudes towards statistics.

Statistics anxiety revealed a significant positive effect on procrastination ($\beta = 1.001$, $p < .001$), thereby validating Hypothesis 4. This result indicates that higher levels of anxiety are associated with increased procrastination, and it is consistent with previous findings reported by Dodeen and Alharballeh [9].

Attitudes towards statistics were found to have a significant negative effect on statistics anxiety ($\beta = -0.477$, $p < .001$), supporting Hypothesis 5. This suggests that more positive attitudes towards statistics are associated with lower levels of anxiety, in line with the findings of Pascual et al. [24].

Furthermore, attitudes towards statistics exerted a significant positive influence on engagement in statistics ($\beta = 0.854$, $p < .001$), confirming Hypothesis 6 and indicating that favourable attitudes are a strong predictor of student engagement, as previously reported by Gopal et al. [5].

Attitudes towards statistics also had a significant positive effect on perceived academic performance ($\beta = 0.211$, $p = .017$), thus validating Hypothesis 7. This finding supports prior evidence suggesting that students' attitudes towards statistics play an important role in academic development [15].

A review of the literature suggests that attitudes towards statistics do not have a statistically significant direct effect on procrastination; however, they play a relevant role within a model mediated by statistics anxiety [12, 25].

The finding for H9, indicating that engagement in statistics does not have a statistically significant effect on perceived academic performance, is not supported by most of the studies reviewed [26].

Procrastination exhibited a significant negative effect on perceived academic performance ($\beta = -0.252$, $p < .001$), providing support for Hypothesis 10. This finding is consistent with that reported by Kim and Seo [27] and Zartaloudi et al. [28].

Regarding the mediation effects, statistics anxiety and procrastination jointly mediated the relationship between attitudes towards statistics and perceived academic performance ($\beta = 0.120$, $p < .001$), thereby

supporting Hypothesis 11 and in accordance with Lethbridge et al. [25]. In addition, procrastination was found to mediate the relationship between statistics anxiety and perceived academic performance ($\beta = -0.252, p < .001$), confirming Hypothesis 12, in line with Macher et al. [29].

4 CONCLUSIONS

The present study sought to advance understanding of the psychological and behavioural factors that shape the learning of statistics in higher education by examining, in an integrated manner, the relationships between self-efficacy, attitudes towards statistics, statistics anxiety, academic engagement, procrastination, and perceived academic performance. Students' experiences in statistics courses are influenced by complex interactions among affective, cognitive, and behavioural processes. Within this framework, self-efficacy is theorised to shape attitudes, engagement, and anxiety, while attitudes are expected to exert broader effects on emotional and behavioural outcomes. Statistics anxiety and procrastination, in turn, function as key mechanisms linking these factors to students' perceptions of academic performance.

By testing a model that incorporates direct, indirect, and mediating effects, this study offers a more comprehensive and systemic perspective on the processes underpinning students' success or difficulty in statistics courses. The findings highlight the central role of attitudes towards statistics within the proposed model. More positive attitudes were associated with lower levels of statistics anxiety, higher academic engagement, and more favourable perceptions of academic performance. In addition to these direct effects, attitudes also exerted a meaningful indirect influence on perceived performance through a sequential pathway involving anxiety and procrastination, underscoring their foundational importance in students' learning experiences in statistics.

Statistics anxiety emerged as a critical risk factor, exerting a strong positive effect on procrastination. This finding suggests that anxiety extends beyond an affective response and manifests in avoidance behaviours that undermine effective time management and sustained engagement with learning tasks. Procrastination, in turn, had a significant negative impact on perceived academic performance, confirming its role as a key mechanism through which affective difficulties translate into poorer academic outcomes. Contrary to expectations, self-efficacy in statistics did not exhibit significant direct effects on anxiety, attitudes, or academic engagement. This unexpected result suggests that, within the context of the present study, the influence of self-efficacy may operate more indirectly or may be contingent upon contextual and pedagogical factors not captured by the model. Similarly, academic engagement did not emerge as a significant direct predictor of perceived academic performance, indicating that effort and participation alone may be insufficient to foster positive performance perceptions when high levels of anxiety and procrastination are present.

From a pedagogical perspective, these findings emphasise the importance of educational approaches that extend beyond the mere transmission of statistical content. Interventions designed to promote positive attitudes towards statistics, reduce anxiety, and support the development of self-regulation and time-management skills may be particularly effective in enhancing students' learning experiences and outcomes. Learning environments that highlight relevance, provide emotional support, and encourage active and contextualised learning are likely to contribute to more positive and sustainable trajectories in statistics education.

Despite its contributions, this study is not without limitations. Its cross-sectional design precludes causal inferences, and the reliance on self-reported measures—particularly perceived academic performance—may introduce response biases. Future research would benefit from longitudinal designs, the inclusion of objective indicators of academic performance, and the examination of potential moderating variables such as disciplinary context, instructional practices, or prior experience with statistics.

Understanding the interplay among these factors is essential for the design of effective interventions to support student success in statistics. By fostering self-efficacy, reducing anxiety, promoting positive attitudes, and encouraging engagement, educators may help to mitigate procrastination and enhance academic performance. Such efforts contribute directly to the development of statistical literacy, a critical competence for evidence-based practice in contemporary society.

In conclusion, this study demonstrates that learning statistics in higher education is shaped by a tightly interconnected set of affective and behavioural factors. By highlighting the central roles of attitudes, anxiety, and procrastination, it reinforces the need for an integrated approach to statistics education that supports students not only cognitively but also emotionally and in terms of self-regulation, thereby promoting more effective engagement and improved academic performance.

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