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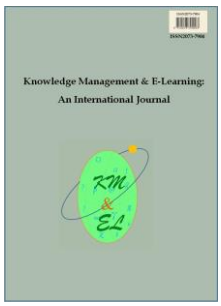

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The influence of technostress on anxiety disorder in higher education students during the Covid-19 pandemic

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Abstract: This article aimed to investigate the relationship between technostress and anxiety disorder in Brazilian public higher education students during the COVID-19 pandemic. The quantitative study was based on primary data (n = 1981) collected through the structured questionnaire of a population of Brazilian public higher education students. Partial least squares structural equation modelling method and multigroup analysis were used for data analyses and to compare the constructs. Of the five dimensions of technostress analysed, techno-uncertainty and techno-complexity did not influence generalized anxiety disorder. Nonetheless, the results demonstrated that technostress was present in the lives of the students studied, demonstrating significant relationships with generalized anxiety disorder. Therefore, this study presents relevant reflections regarding prolonged exposure and additional factors that technology influenced students' quality of life, thus generating

strategic alignments to improve the mental health of students who went through the remote teaching process imposed by the COVID-19 pandemic.

Keywords: Technostress; Anxiety disorder; Covid-19 pandemic; Student

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1. Introduction

The constant use of technology during the remote teaching process in the context of the COVID-19 pandemic increased the technostress and anxiety index of various higher education students (Xiao et al., 2020; Essel et al., 2021; Oladele et al., 2022; Sharma &

Gupta, 2023). Studies, such as the one conducted by Alvarez-Risco et al. (2021) in Peru, have demonstrated that technostress contributes to the exhaustion experienced by university students.

Technostress arises from an individual's constant exposure to technology, and this condition was exacerbated by the COVID-19 pandemic for university students, given their intensive use and reliance on digital devices and resources (Upadhyaya & Vrinda, 2021). For Clark and Kalin (1996), technostress is associated with individuals' difficulties adapting to technological changes. In this context, the relationships between technology, stress, and mental health are particularly noteworthy (Dragano & Lunau, 2020).

Furthermore, insecurity regarding the use of technology often leads students to believe that their knowledge is insufficient. This perception triggers technological insecurity and fosters a feeling of being threatened (Wang et al., 2020; Upadhyaya & Vrinda, 2021; Weldon et al., 2021; Limbu & Pham, 2023). A study carried out in Ghana by Essel et al. (2021) demonstrated the adverse effects of technostress on academic performance, showing that technostress not only negatively impacts academic performance but also contributes to increased school dropout rates and a lack of attention to academic tasks. Torales et al. (2022) empirically confirmed significant associations between technostress, anxiety, and depression in Paraguayan university students, whereas Deng et al. (2021) also confirmed a higher prevalence of depressive and anxiety symptoms during the pandemic.

The restrictive measures and social isolation imposed by the COVID-19 pandemic have significantly impacted the mental health of the general population, particularly among students; this period has seen a heightened focus on anxiety disorder (Huang & Zhao, 2020; Mohammadi & Shahyad, 2020; Stein, 2020). Anxiety disorders are relatively common, affecting 22% of patients who report anxiety-related issues. Despite its prevalence, it remains one of the least treated disorders, largely due to a limited understanding of its underlying pathophysiology (Li et al., 2020; Wittchen, 2002).

During the COVID-19 pandemic, researchers reported a higher prevalence of anxiety disorders among university students (Muzaffar et al., 2022; Brunett et al., 2023). For instance, Muzaffar et al. (2022) investigated university students from Bangladesh and confirmed that women are 2.21 times more likely to develop anxiety disorders than men. Cao et al. (2020) showed the impact on the mental health of university students during the pandemic and found that 0.9% of the 7,143 survey respondents had a severe anxiety disorder, which was aggravated in cases where they had infected acquaintances and when there were delays in their academic activities. Hossain et al. (2020) added that exposure to social and electronic media contributed to increasing anxiety disorder since the constant search for information and increasingly unfavourable results regarding the numbers of infected and diseased have aggravated anxiety levels. Thus, the population, especially students, became more dependent on technology for their daily and academic activities, increasing anxious states given the need to manage and reconcile conflicts, time management, work, studies, and family, generating the so-called technostress (Olasina & Kheswa, 2021; Galvin et al., 2022). In emerging countries such as Brazil, the pandemic negatively affected the educational sector, especially through the cut of public resources and the dropout of higher education students, consequently impacting their lives, routine, and mental health (Arenas et al., 2021; Feter et al., 2021; Woicolesco et al., 2022). Given the above, this article aims to investigate the relationship between technostress and anxiety disorder in Brazilian public higher education students during the COVID-19 pandemic.

This study is relevant given the lack of research on technostress, particularly in higher education students (Penado Abilleira et al., 2020). Furthermore, the prevalence of technostress tends to lower productivity and increase academic dropout rates (Upadhyaya & Vrinda, 2021). Moreover, this article contributes to decision-making by educational system managers, especially in periods of instability and crisis, as it is necessary to review strategic guidelines for higher education due to the likely negative implications caused by technostress in anxiety disorder during the pandemic. De Godoy et al. (2021) emphasized the need to address the impact on students' mental health due to the sudden shift to remote work.

The present study is organized as follows. Section 2 presents technostress and anxiety disorder, followed by the methodological procedures and steps in Section 3. Section 4 presents the results and discussions based on the analyses performed, and lastly, the final considerations in Section 5, which highlights the main findings, limitations, and suggestions for future studies.

2. Theoretical framework

2.1. Technostress and anxiety disorder

The formal definition of technostress emerged in the 1980s with the release of a book of the same title (Brod, 1984). The term was conceptualized as any physical and behavioral negative impact caused by the direct or indirect use of technology (Weil & Rosen, 1997). According to Torales et al. (2022, p.1063), "Technostress is a modern term referring to stress levels caused by prolonged exposure to technology." Technostress can be understood as a pathology resulting from human adaptation in conditions of scarce cognitive skills associated with using technological resources. Other definitions for such an event have also been established among experts on the subject, and, in consensus, technostress became widely accepted as a negative psychophysiological state arising from the constant use of digital technologies (Salla et al., 2022).

This condition can generate changes in psychophysiological levels, so individuals begin to assume a negative attitude when using technologies. Thus, when individuals present a psychophysiological state altered by technostress, there is a perceptual incompatibility of existing technological resources with their cognitive capabilities to use them (Salla et al., 2022). Ragu-Nathan et al. (2008) defined five factors or dimensions as causes of technostress, namely: techno-overload (the individual is forced to work more and for a longer period because of technology), techno-invasion (the individual can be reached in any place or time by technologies), techno-complexity (the effort required to learn to use technologies), techno-insecurity (the individual feels threatened with losing their job or that others are more qualified for the tasks), and techno-uncertainty (discomfort in the face of constant technological changes).

In this sense, technological overload is similar to role overload, as both imply altered or increased demands on the individual. Techno-invasion corresponds to the invasive effect of technologies in situations where people can be reached at any time, and there is a need to be constantly connected, confusing this professional context with the personal one. In turn, techno-complexity is similar to task difficulty and implies the presence of conditions that the individual considers difficult to understand technologies. It describes situations in which technology's complexity makes users feel deficient in skills and forces them to spend time and effort learning and understanding technologies

(Ragu-Nathan et al., 2008). Techno-insecurity is associated with situations where people feel threatened with losing their jobs, either because of automation or because of other people who are more proficient with technology; it is the insecurity of being unnecessary or replaced by someone more skilful. Finally, techno-uncertainty refers to contexts where continuous changes and updates disturb users, so they must constantly learn about new technologies (Ragu-Nathan et al., 2008).

Little has been done to expand the findings regarding technostress. As a result, recent surveys continue to show mixed results (Özgür, 2020; Qi, 2019). Özgür (2020) showed that, due to rapid innovation, adaptations are necessary for the strategic alignment of planning in the education sector. The overload of teaching work caused by information and communication technologies can influence technostress development. Qi (2019) reported that individuals' activity can influence the results. Thus, the use of technology by university students does not significantly influence technostress, although the authors emphasized that university students are digital natives, unlike most other workers.

Anxiety states can be diagnosed in different situations, including generalized anxiety disorder (GAD) (Martin, 2003). This condition is characterized by persistent and excessive concern with different experiences and projections of future scenarios, in which individuals find it difficult to control their thoughts, especially focused on worst-case scenarios (American Psychiatric Association, 2014; Stein & Sareen, 2015; Schönhofen et al., 2020). In turn, anxiety disorder is a condition in which affected individuals tend to demonstrate intense concern in a sustained and even uncontrolled manner, much more intense than daily anxiety (Castillo et al., 2000; Lopes et al., 2020). Thus, anxiety disorder is a psychiatric disorder characterized by the excessive and uncontrollable manifestation of anxiety and worry associated with various symptoms, capable of negatively interfering with patients' quality of life (Moreno-Peral et al., 2017; Chen et al., 2020).

The experience of uncertainty and a feeling of insecurity aggravated the incidence of anxiety disorder among university students in the context of the COVID-19 pandemic and technostress (Upadhyaya & Vrinda, 2021; Muzaffar et al., 2022; Torales et al., 2022; Galvin et al., 2022; Brunett et al., 2023). Fawaz and Samaha (2021) noted that technostress is recurrent and associated with psychological and behavioral disorders, such as anxiety disorder. Positive associations between techno-overload, work-home conflict anxiety, and depressive symptoms were discovered by Galvin et al. (2022) with university students from Greece, Italy, and the United Kingdom. In another study, Torales et al. (2022) proved that technostress levels were significantly associated with anxiety disorder in Paraguay. Given this concerning scenario, the importance of testing the following hypotheses is perceived:

H₁: Techno-overload influences anxiety disorder.

H₂: Techno-uncertainty influences anxiety disorder.

H₃: Techno-insecurity influences anxiety disorder.

H₄: Techno-complexity influences anxiety disorder.

H₅: Techno-invasion influences anxiety disorder.

Furthermore, the differences between genders regarding the propensity to develop both technostress and anxiety disorder have been reported in the literature, and researchers have shown the differences between genders with higher levels of

technostress and anxiety (Vasiliadis et al., 2020; Penado Abilleira et al., 2021). Thus, based on the aforementioned authors, the following hypothesis may be stated:

***H*$_{6a-e}$**: Gender influences the relationships between the technostress dimensions and anxiety disorder.

Ragu-Nathan et al. (2008), Dragano and Lunau (2020), and Nisafani et al. (2020) claimed that the digitization of work, as well as the high range of activities that were added through remote work, such as fast learning to use technology, can generate technostress. Other studies have demonstrated that remote work caused by COVID-19 restrictions has led to workers presenting higher levels of anxiety, poor sleep quality, and stress caused by the heavier workload (Como et al., 2020; Savolainen et al., 2021). Given these premises, the following hypothesis may be stated:

***H*$_{7a-e}$**: Work influences the relationships between the technostress dimensions and anxiety disorder.

2.2. Hypothesis analysis of the relationship between technostress and anxiety disorder

The path model was created with the hypotheses and relationships between the dimensions proposed by the authors, following the step-by-step process proposed elsewhere (Fig. 1) (Hair et al., 2017; Lopes et al., 2020). In this model, male and female genders and (un)employed students were compared by MGA, as proposed by Nguyen-Phuoc et al. (2021). Fig. 1 presents the 15 proposed hypotheses to be confirmed or refuted by the structural model.

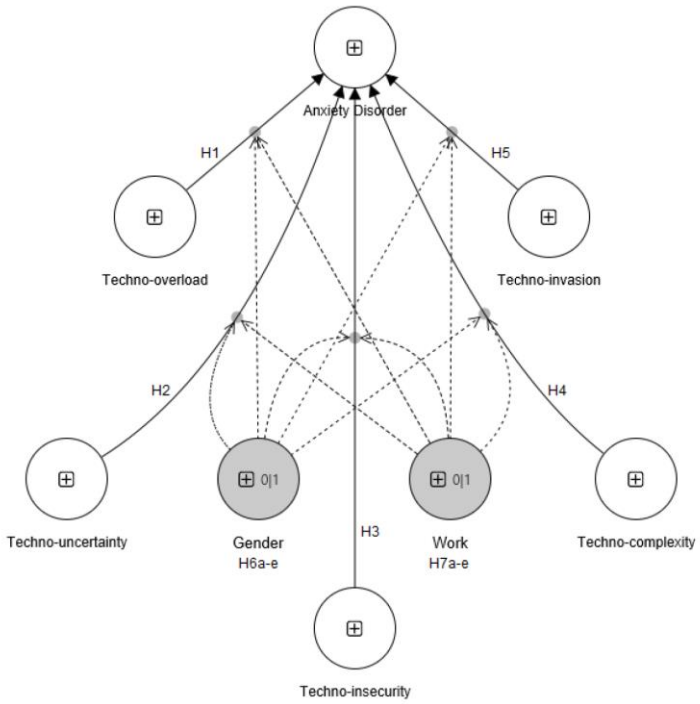

Fig. 1. Suggested measurement model

3. Method

Database searches (e.g., Scopus and Web of Science) revealed a theoretical gap between themes involving anxiety disorder and technostress. To assess students' anxiety levels, we utilized the Generalized Anxiety Disorder (GAD-7) scale developed by Spitzer et al. (2006) and validated by Kroenke et al. (2007). It is a self-report instrument used to evaluate the general symptoms of anxiety described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), consisting of seven questions that are scored using a four-point scale ranging from 0 (never) to 3 (almost every day). The final score achieved by the GAD-7 is 0–21 points, where the higher the score, the greater the severity of the symptoms of generalized anxiety; the severity of the symptoms ranges between 0–4 points (minimal anxiety), 5–9 points (mild anxiety), 10–14 points (moderate anxiety), and 15–21 points (severe anxiety).

The instrument of Ragu-Nathan et al. (2008) was used to identify the elements that create technostress and adapt to the context and network activities. It consists of 21 questions subdivided into five dimensions: Techno-overload refers to occasions when technologies cause individuals to speed up their work and prolong their activities. Techno-invasion is how technologies make individuals rely on constant connection, with no separation between work and personal life. Techno-complexity concerns situations where the person does not feel adequate to use technologies, causing them to spend more and more time and effort acquiring technology-related knowledge. Techno-insecurity comprises occasions when individuals tend to think that they will lose their jobs to technology or other people who understand better about these new technologies. Lastly, techno-uncertainty refers to moments when constant changes and updates to technology cause individuals to become concerned since they must be constantly learning about these technologies (Ragu-Nathan et al., 2008).

The scale was originally developed and used in the workplace of information technology users (Ragu-Nathan et al., 2008). For this study, the questionnaire was adapted to survey higher education students, highlighting that the reason for using this scale was because it is a widely used scale and would best suit the higher education students researched. It should be noted that the questions were arranged on a five-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree).

The population participating comprised 1981 higher education and graduate students from Brazilian public universities, where the research instruments and confidentiality and informed consent forms were sent to the respondents. This study is part of a project registered and was approved by the Ethics Committee (CAAE/CONEP no. 44261821.8.0000.5346 and no. 4,606,945). An online questionnaire was applied from March to April 2021, amid the COVID-19 pandemic, as changes in the social and educational context may have affected students' mental health in some way.

To assess the possible relationships between the dimensions of technostress and anxiety disorder, partial least squares structural equation modelling (PLS-SEM) and multigroup analysis (MGA) were used to assess the influence of gender and the existence of labor activity. The PLS-SEM was chosen as it enables one to estimate models and the relationships between the dimensions and their respective indicators based on previously established criteria, in addition to estimating the predictive path model (Ringle et al., 2014; Hair et al., 2021). The PLS-SEM algorithm was run using the SmartPLS® software (version 4.0.9.9) (Ringle et al., 2022).

Additionally, the method included confirmatory factor analysis techniques, which are suitable for predicting and relating key dimensions or identifying driving dimensions,

as well as comparing groups in pairs (Hair et al., 2017). The measurement model has five parameters (β's) that connect the five exogenous dimensions to an endogenous dimension (latent variables) and the 28 indicators (observed variables), and when structured in a multigroup way, the models have 15 hypotheses, five of them comparing gender and five comparing employed and unemployed students (Hair et al., 2014).

4. Analysis and presentation of the results

4.1. Initial analyses of mental health and sociodemographic data

This section presents the results from the instruments and analyses utilized, and Table 1 lists the data reported by the respondents.

As shown in Table 1, the gender with the greatest representation was female at 59.31%, with 40.68% male. Regarding the age group, 61.43% were 25 or younger, representing a relatively young group. As for employment status, 43.56% of respondents were employed, with 25.69% working on-site and 17.87% remotely, whereas 56.44% were not employed during the survey period.

Table 1
Sociodemographic data (n = 1,981)

Variables		*n*	%
Gender	Male	806	40.68
	Female	1,175	59.31
Age (years)	≤ 25	1,217	61.43
	26-35	440	22.21
	≥ 36	324	16.36
Employment status			
Employed	On-site	509	25.69
	Remotely	354	17.87
Unemployed		1,118	56.44

4.2. Structural model analysis

The algorithm programmed in SmartPLS® was configured for seven criteria; the weighting based on the path was the parameterized system, providing a value for the coefficient of explanation (R^2) that was more expressive for the endogenous dimensions (predictive variables). The number of iterations was set to 300, representing the maximum number used to calculate PLS results. The initial weights for external indicators were set to 1.0 (Hair et al., 2017).

To reach the minimum values of the assumptions for the convergent validity of the measurement model, the following indicators were excluded: TU_03 (λ = 0.007), TIN_02 (λ = 0.423), and TIN_04 (λ = 0.458), increasing Cronbach's α (α > 0.8) and the average variance extracted (AVE > 0.5). After excluding the indicators, Table 2 and Fig. 2 show the convergent validity of the model.

The evaluation of internal consistency uses Cronbach's α (CA) as a traditional criterion, which is an estimate of reliability based on the intercorrelations of the observed

variables and the composite reliability (CR), which vary between 0 and 1 (Hair et al., 2017; Lopes et al., 2020). Values between 0.70 and 0.90 are considered good and efficient, while values above 0.90 are undesired (especially above 0.95) as they may indicate that the respondents may have redundancy in their answers. In the case of Table 2, the minimum values for α and CR were 0.808 and the maximum was 0.941. For the authors, AVE > 0.50 indicates that, on average, the dimension explains over half of the variance of their indicators. In Table 2, the minimum value was 0.588.

Table 2
Internal consistency measures and convergent validity of the model

Latent variables	CA	CR	AVE
Anxiety disorder	0.927	0.941	0.675
Techno-complexity	0.897	0.928	0.761
Techno-insecurity	0.844	0.808	0.588
Techno-invasion	0.824	0.883	0.638
Techno-overload	0.878	0.912	0.669
Techno-uncertainty	0.844	0.849	0.729

Note. SmartPLS® software v. 4.0.9.9 (Ringle et al., 2022)

Fig. 2 presents the initial model, the value of the factor loadings, and the final AVE values.

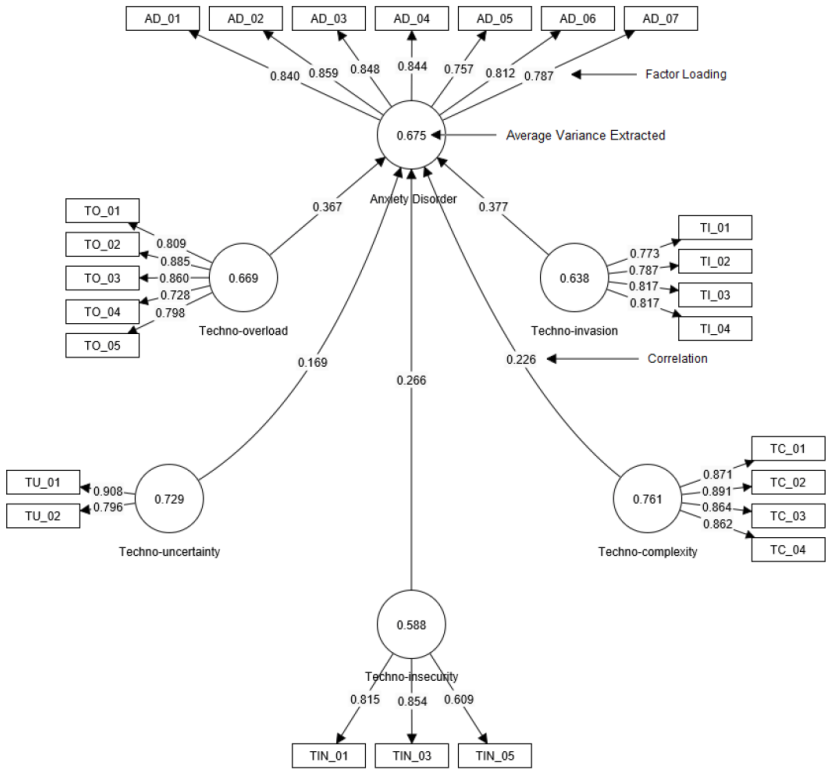

Fig. 2. Proposed model, factor loadings, correlation, and AVE values

The path model shows the cross-factor loadings, the correlation of indicators with their respective dimensions, the structural coefficients between the dimensions, and the AVE (Fig. 2) (Hair et al., 2017; Lopes et al., 2020). Next, the convergent validity of the model was evaluated using the two most traditional and efficient techniques to analyze the convergent validity: the Fornell-Larcker (FL) and Heterotrait-Monotrait (HTMT) ratio criterion (Fornell & Larcker, 1981), which compares the AVE values of each dimension with the Pearson's correlation matrix values between the dimensions. The square roots of the AVE must be greater than the correlations between the dimensions and the HTMT, being more efficient than FL as it may not identify a possible discriminant validity of the model (Hair et al., 2017; Lopes et al., 2020). Table 3 presents the comparative values for correlation and AVE root and the HTMT ratio using the bootstrapping method for 5,000 subsamples.

Table 3 demonstrates that the proposed model meets the FL criterion since the square root values of the AVE of the dimensions are greater than the values of the correlation matrix. As for the HTMT ratio, the upper limit of the 95% confidence interval results is below 1.00, indicating a possible discriminant validity of the model.

Table 3
Discriminant validity analysis using the Fornell-Larcker and Heterotrait-monotrait ratio for the model

Latent variables	$\sqrt{\text{AVE}}$	Pearson's correlation matrix					
		1	2	3	4	5	6
Anxiety disorder (1)	0.822	1.000					
Techno-complexity (2)	0.872	0.226	1.000				
Techno-insecurity (3)	0.767	0.266	0.745	1.000			
Techno-invasion (4)	0.799	0.377	0.452	0.453	1.000		
Techno-overload (5)	0.818	0.367	0.429	0.437	0.688	1.000	
Techno-uncertainty (6)	0.854	0.169	0.229	0.288	0.278	0.262	1.000
		Upper Limit (HTMT)$_{97.5\%}$					
Techno-complexity (2)		0.324					
Techno-insecurity (3)		0.451	0.977				
Techno-invasion (4)		0.479	0.556	0.659			
Techno-overload (5)		0.487	0.518	0.624	0.840		
Techno-uncertainty (6)		0.223	0.349	0.512	0.438	0.410	

Note. Heterotrait-monotrait ratio: HTMT; anxiety disorder: AD; techno-complexity: TC; techno-insecurity: TIN; techno-invasion: TI; techno-overload: TO; techno-uncertainty: TU

With regard to Table 4, the model was evaluated for its structural validity, allowing it to be evaluated for its predictive capacity. The systematic approach to evaluate the structural model began by analysing the multicollinearity between the exogenous and endogenous (predictive) dimensions. This is typically evaluated by the variance inflation factor, which must be less than 5, indicating the non-existence of strong correlations between the dimensions (Hair et al., 2017).

Another measure is the explanation coefficient (R^2), which is the measure of the predictive capacity of the structural model. The values are classified as having weak ($0.02 \leq R^2 \leq 0.075$) moderate ($0.075 < R^2 \leq 0.19$), and strong effect ($R^2 > 0.19$), as recommended by Lopes et al. (2020) and adapted from Cohen et al. (1998). The model was then evaluated for its effects (f^2) and confirmed by the bootstrapping method. The

effects between dimensions can be classified as small ($0.02 \leq f^2 \leq 0.075$), medium ($0.075 < f^2 \leq 0.225$), and large ($f^2 > 0.025$). This classification was proposed by Lopes et al. (2020) and adapted from Cohen et al. (1998).

Finally, the model was evaluated for its predictive relevance (Q^2). According to Hair et al. (2017), the Q^2 values estimated by the blindfolding process represent a measure of how well the path model can predict the originally observed values, and this value, related to the endogenous dimension, should be greater than zero.

Table 4
Variance inflation factor values and the R^2, f^2 and Q^2 effect for the model

Exogenous dimension	Anxiety disorder Variance Inflation Factor	f^2 (p-value)
Techno-complexity	2.343	0.001 (0.545)
Techno-insecurity	2.402	0.015 (0.010)
Techno-invasion	2.052	0.017 (0.008)
Techno-overload	1.989	0.036 (0.000)
Techno-uncertainty	1.129	0.001 (0.669)
	R^2 (p-value)	0.199 (0.000)
	Q^2	0.138

Table 4 shows that techno-complexity and techno-uncertainty have a small and insignificant effect on the anxiety disorder dimension, which may affect the significance of the relationship (hypotheses) between these dimensions. As for the other significant effects, techno-insecurity and techno-invasion have a medium effect on the anxiety disorder dimension, and techno-overload has a large effect. As for the explanation coefficient, the model has a strong effect ($R^2 > 0.19$) and predictive relevance above zero.

Table 5 shows the values of the relationships between the exogenous dimensions and the predictive dimension of anxiety disorder, considering the structural coefficient value (β), t-statistics, and p-values resulting from the evaluation of the hypotheses proposed in the model.

Table 5
Results of the hypotheses of the model

	Hypotheses	β	t-statistic	p-value	Result
H_1	Techno-overload influences anxiety disorder	0.238	8.103	0.000	Accepted
H_2	Techno-uncertainty influences anxiety disorder	-0.022	0.991	0.322	Refuted
H_3	Techno-insecurity influences anxiety disorder	0.167	5.316	0.000	Accepted
H_4	Techno-complexity influences anxiety disorder	-0.040	1.329	0.184	Refuted
H_5	Techno-invasion influences anxiety disorder	0.167	5.477	0.000	Accepted

As one can observe in the effect values (f^2) in Table 5, Hypotheses 2 and 4 were refuted since the β values were not statistically significant ($p < 0.05$). In contrast, Hypotheses 1, 3, and 5 presented significant β values and were therefore confirmed. A comparative analysis was then conducted between genders (female n = 1,175; male n = 806) and between groups of individuals employed (n = 863) and unemployed (n = 1,118). Evidence has shown that women are more likely to develop technostress as students in the initial semesters of higher education courses (Wang et al., 2020; Lischer et al., 2022; Upadhyaya & Vrinda, 2021). In the following analysis, the results of the moderating

effects of gender and functional category using MGA were presented; MGA is used to statistically understand the significant differences between two groups (male and female participants) and the categories (female/male and (un)employed) in relation to technostress and anxiety disorder. Before performing the MGA, the measurement invariance of composite models was tested using the three-step procedure (Henseler et al., 2016). Nguyen-Phuoc et al. (2021) suggested three steps, namely Step 1) configural invariance assessment, Step 2) establishment of compositional invariance assessment, and Step 3) assessment of equal means and variances (Tables 6a and 6b).

Table 6a
Results of invariance measurement testing using permutations (Steps 1 and 2)

Dim.	Step 1	Step 2				Partial measurement invariance established
	Configural invariance (same algorithm for both groups)	Compositional invariance				
		Original correlation	Confidence interval	*p*-value		
				F-M	Y-N	
AD	Yes	1.000	[1.000; 1.000]	0.596	0.762	Yes
TC	Yes	1.000	[0.998; 1.000]	0.661	0.177	Yes
TIN	Yes	0.997	[0.991; 1.000]	0.251	0.473	Yes
TI	Yes	1.000	[0.998; 1.000]	0.925	0.782	Yes
TO	Yes	0.999	[0.997; 1.000]	0.199	0.231	Yes
TU	Yes	0.994	[0.990; 1.000]	0.434	0.128	Yes

Table 6b
Results of invariance measurement testing using permutations (Step 3)

Dim.	Step 3 - part 1 Mean original difference				Step 3 - part 2 Variance original difference				Full measurement invariance established
	(F-M)	CI	*p*	Equal	(F-M)	CI	*p*	Equal	
AD	0.054	[-0.085; 0.086]	0.272	Yes	-0.077	[-0.096; 0.105]	0.363	Yes	Yes
TC	0.058	[-0.090; 0.093]	0.267	Yes	0.035	[-0.108; 0.098]	0.520	Yes	Yes
TIN	0.094	[-0.091; 0.090]	0.133	Yes	0.069	[-0.095; 0.103]	0.380	Yes	Yes
TI	0.082	[-0.083; 0.088]	0.126	Yes	-0.031	[-0.105; 0.107]	0.515	Yes	Yes
TO	0.074	[-0.090; 0.080]	0.109	Yes	-0.036	[-0.116; 0.121]	0.505	Yes	Yes
TU	0.050	[-0.086; 0.087]	0.274	Yes	-0.058	[-0.135; 0.140]	0.426	Yes	Yes
	(Y-N)	CI	*p*	Equal	(Y-N)	CI	*p*	Equal	
AD	-0.084	[-0.089; 0.094]	0.108	Yes	0.090	[-0.094; 0.127]	0.170	Yes	Yes
TC	-0.002	[-0.088; 0.096]	0.964	Yes	0.055	[-0.112; 0.113]	0.323	Yes	Yes
TIN	-0.063	[-0.063; 0.088]	0.172	Yes	0.038	[-0.104; 0.099]	0.474	Yes	Yes
TI	0.066	[-0.066; 0.087]	0.147	Yes	0.053	[-0.088; 0.094]	0.312	Yes	Yes
TO	0.097	[-0.089; 0.086]	0.112	Yes	0.056	[-0.122; 0.119]	0.345	Yes	Yes
TU	0.028	[-0.099; 0.087]	0.563	Yes	0.095	[-0.140; 0.135]	0.180	Yes	Yes

Note. F-M: female-male; Y-N: yes-no; confidence interval: CI; anxiety disorder: AD; techno-complexity: TC; techno-insecurity: TIN; techno-invasion: TI; techno-overload: TO; techno-uncertainty: TU

The MGA results are presented in Tables 7a and 7b. Both methods were used: Henseler's MGA test (the non-parametric method) and the permutation test. In Henseler's MGA and permutation test, a p-value below 0.05 demonstrates significant differences between specific path coefficients across two groups at a significance level of 5%.

Table 7a
Multigroup analysis results: female (F) vs. male (M)

Hyp.	Relationship	PC (F-M)	*p*-value (difference) Henseler's test	Permutation test	Result
H_{6a}	TO → AD	0.052	0.400	0.391	No/No
H_{6b}	TU → AD	-0.038	0.404	0.399	No/No
H_{6c}	TIN → AD	0.173	0.008	0.007	Yes/Yes
H_{6d}	TC → AD	-0.123	0.045	0.048	Yes/Yes
H_{6e}	TI → AD	-0.100	0.108	0.109	No/No

Note. Path coefficients: PC; anxiety disorder: AD; techno-complexity: TC; techno-insecurity: TIN; techno-invasion: TI; techno-overload: TO; techno-uncertainty: TU

Table 7b
Multigroup analysis results: employed (Y) vs. unemployed (N)

Hyp.	Relationship	PC (Y-N)	*p*-value (difference) Henseler's test	Permutation test	Result
H_{7a}	TO → AD	0.137	0.020	0.020	Yes/Yes
H_{7b}	TU → AD	0.077	0.102	0.109	No/No
H_{7c}	TIN → AD	0.037	0.559	0.566	No/No
H_{7d}	TC → AD	0.020	0.746	0.771	No/No
H_{7e}	TI → AD	-0.142	0.019	0.023	Yes/Yes

Gender was shown to influence the relationship between techno-insecurity and anxiety disorder (H_{6c}) and the relationship between techno-complexity and anxiety disorder (H_{6d}); it is important to note that, in the general model, Hypothesis H_{6d}—which is equivalent to H_4—was not statistically significant (Table 7a). Employment status was also found to influence the relationship between techno-overload and anxiety disorder (H_{7a}) and techno-invasion and anxiety disorder (H_{7e}) (Table 7b). Fig. 3 and Table 8 summarize the findings of the relationships and comparative analyses and present the final structural model.

By analyzing Table 8, one can observe that women and students who are unemployed have the same structural coefficients as the general model (i.e., anxiety disorder is related to techno-overload, techno-insecurity, and techno-invasion). In contrast, the men had the same structural coefficients as employed students (i.e., anxiety disorder is related to techno-overload and techno-invasion).

Table 8
Final path diagram for structural equations of the model

Endogenous dimensions	=	Exogenous dimensions	+	Error
$AD_{general}$	=	0.238 TO + 0.167 TIN + 0.167 TI	+	ε_{AD}
AD_{female}	=	0.240 TO + 0.232 TIN + 0.134 TI	+	$\varepsilon_{ADfemale}$
AD_{male}	=	0.188 TO + 0.234 TI	+	ε_{ADmale}
$AD_{employed}$	=	0.322 TO + 0.179 TIN	+	$\varepsilon_{ADemployed}$
$AD_{unemployed}$	=	0.185 TO + 0.142 TIN + 0.228 TI	+	$\varepsilon_{ADunemployed}$

Note. Anxiety disorder: AD; techno-complexity: TC; techno-insecurity: TIN; techno-invasion: TI; techno-overload: TO; techno-uncertainty: TU

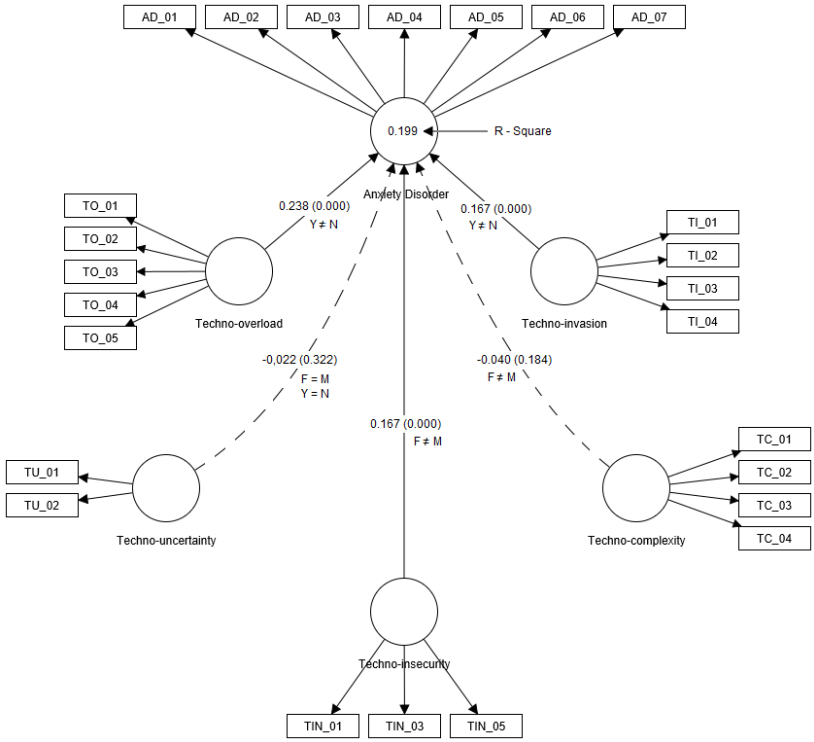

Fig. 3. The final measurement of the multigroup model
Note. Employed: Y; Unemployed: N; Female: F; Male: M

5. Discussion of the results

The rapid changes made to online teaching in education institutions due to the COVID-19 pandemic directly influenced the levels of anxiety, depression, and stress in university students (Fawaz & Samaha, 2021). Our results demonstrated that techno-overload influences anxiety disorder, confirming Hypothesis H_1. Hence, the study conducted by Fawaz and Samaha (2021) with Lebanese university students during the pandemic context corroborated the confirmation by demonstrating that the intensive use of technology is mainly due to an excessive workload and has influenced anxiety disorders. Furthermore, Galvin et al. (2022) also helped to confirm Hypothesis H_1, as it demonstrated that techno-overload is directly associated with higher anxiety levels. Furthermore, there was no difference when considering the analysis according to gender, although separate analyses between employed and unemployed individuals revealed a difference, confirming Hypothesis H_{7a}.

As for Hypothesis H_2, no significant relationship of influence was found between techno-uncertainty and anxiety disorder, so H_2 was rejected (i.e., technostress does not influence anxiety disorder). This finding differs from Califf and Brooks (2020), who demonstrated the influence of techno-uncertainty on the existence of burnout. However, the hypothesis was refuted in the sample studied and associated with anxiety disorders. Hypothesis H_3 (techno-insecurity influences anxiety disorder) was accepted. As far as higher education is concerned, techno-insecurity may suggest a different development from the work environment. In the case of academics, it is characterized by the threat of

peers having more technological skills and, therefore, performing activities better. In addition, frequent updating generates uncertainty in students (Upadhyaya & Vrinda, 2021).

Nonetheless, it is common for students to feel insecure about their peers' performance. Upadhyaya and Vrinda (2021) pointed out that peer pressure overlaps with insecurity regarding the need for updating. There was no difference in the hypothesis in the analysis regarding whether people were employed. However, this was the only hypothesis that demonstrated a significant difference in the gender MGA, which confirmed Hypothesis H_{6c} and corroborated Vasiliadis et al. (2020), Penado Abileira et al. (2021), and Muzaffar et al. (2022). Unlike what was expected, no significant relationship of influence was found between technocomplexity and anxiety disorder; therefore, H_4 was refuted. Qi (2019) mentioned that students are more immersed in technology, not having any difficulties to the point that it can affect the construct of anxiety disorder.

Our proposition that techno-invasion influences anxiety disorder was accepted. The result demonstrated for Hypothesis H_5 corroborates Diller et al. (2016), who demonstrated that the techno-invasion dimension is related to emotional exhaustion and stress. Moreover, Torales et al. (2022) also showed a significant influence between technostress and anxiety disorder. Techno-invasion is perceived when technology invades students' personal lives, influencing their productivity (Upadhyaya & Vrinda, 2021). Hypothesis H5 is also corroborated by other studies, including Oladosu et al. (2020) and Molino et al. (2020), who demonstrated that techno-invasion increases work-family conflict rates, mainly due to the constant influence of technology on the individual's private life, thereby leading to possible situations of stress, anxiety, and depression (Zainal Badri & Wan Mohd Yunus, 2022). When related to gender, there was no difference since the hypothesis was rejected in this context (Torales et al., 2022). However, when one considers the possibility of an individual being employed, the hypothesis is influenced, thus confirming Hypothesis H_{7e}.

Researchers have already recommended that the mental health of university students should be monitored, especially in exceptional contexts such as a pandemic (Cao et al., 2020). When we investigated the relationship between technostress and anxiety disorder in Brazilian public higher education students during the COVID-19 pandemic, we highlighted important aspects that influenced mental health, especially by demonstrating the main dimensions of this psychological state and its influence on anxiety. Our findings showed that techno-overload, techno-insecurity, and techno-invasion influenced anxiety disorder for the participating students.

Regarding the MGA, we found that Hypothesis H_3 (techno-insecurity influences anxiety disorder) was influenced by gender (H_{6c}). Despite H_4 being refuted, a difference was found in the result when gender was considered, with H_{6d} being accepted and leading to the conclusion that gender influenced the proposition that techno-complexity influences anxiety disorder. Our findings raise important considerations in favor of promoting the mental health and well-being of higher education students, particularly given the negative influence of excessive technology on anxiety disorder for Brazilian higher education students (Peloso et al., 2020; Alves et al., 2021; Pereira et al., 2021). Using MGA, employed (Y) vs. unemployed (N), Hypothesis H7a and H7e were accepted.

Faced with various challenges that have systematically affected educational systems in multiple countries, the situation in Brazil has been particularly difficult. Until recently, a lack of technological infrastructure has forced many students to quickly adapt to new circumstances, which often meant purchasing new equipment and adjusting to a different way of learning. Additionally, specific resources mandated by federal and state

laws were required for this transition. This was especially true for students living in more remote areas who did not have access to the necessary equipment, a stable internet connection, or the financial means to make these adjustments. Ultimately, these challenges may have exacerbated symptoms of anxiety and technostress (Brasil, 2022a; Brasil, 2022b; Schuch et al., 2023).

6. Conclusion, limitations, and suggestions for future research

This study aimed to evaluate the relationship between technostress and anxiety disorder in Brazilian public higher education students during the COVID-19 pandemic. The changes caused by the pandemic have impacted the mental health of the population, especially students, as confirmed by the responses of 1,981 Brazilian higher education students and aided by the theory addressing the themes in question. The study also sought to answer the research question: what is the relationship between technostress and anxiety disorder in Brazilian public higher education students during the COVID-19 pandemic? To begin, relationships between the analyzed constructs were found, as out of the five hypotheses regarding the relationships between the themes, only two were refuted (H2: techno-uncertainty influences anxiety disorder; H_4: techno-complexity influences anxiety disorder), demonstrating that uncertainty regarding the use of technologies does not influence students' anxiety. This can be explained by Qi (2019), who claimed that university students are digital natives, unlike most other workers.

As for the relationships of the analyses using the multigroup model, five hypotheses considered gender ($H_{6a\text{-}e}$), of which, according to the analysis, only techno-insecurity (H_{6c}) and techno-complexity (H_{6d}) were influenced by gender and had a relationship with anxiety disorder. Upadhyaya and Vrinda (2021) reported higher levels of technostress among female students than their male counterparts. However, gender was not found to influence the population of this study. The last analysis verified the relationship of the constructs, as mediated by the employment status, demonstrating that only Hypotheses H_{7a} and H_{7e} had an influence, since the latter had an inverse relationship given it has negative path coefficients.

This study is relevant because the changes that occurred due to the pandemic influenced the population's health, as the entire educational system had to shift quickly to remote education without training or prior preparation. Consequently, analyzing whether technostress influences students' anxiety disorder is essential, as planning is necessary, and the methods utilized must be rethought to avoid illnesses caused by excessive virtual activities. With regard to theoretical implications, this study provides information that helps develop and understand students' mental health in atypical situations, thereby contributing to the literature on technostress and anxiety disorder development.

As for the practical implications, this study provides valuable data for public policymakers and education systems by shedding more light on the concerning reality of students' mental health in terms of remote workload. Indeed, the results can be taken into account to reduce the complexity of integrating students with online platforms, making the virtual environment more attractive and activities more comfortable for students. This is important because the prevalence of technostress tends to reduce productivity and increase academic evasion.

Lastly, interpretations of these results are subject to certain limitations. For instance, this study was conducted only with university students from public universities.

Hence, future studies can seek to investigate and compare private education students, university professors, and civil servants.

Author Statement

The authors declare that there is no conflict of interest.

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