

Article

Contextual Study of Technostress in Higher Education: Psychometric Evidence for the TS4US Scale from Lima, Peru

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Abstract

Sustainable education requires addressing the challenges posed by digital transformation, including technostress among university students. This study evaluates technostress levels in higher education through the validation of the TS4US scale and its implications for sustainable learning environments. A cross-sectional study was conducted with 328 university students from four districts in Lima, Peru, using an online survey to measure technostress. Confirmatory factor analysis (CFA) was performed to assess the psychometric properties of the TS4US scale, resulting in a refined model with two latent factors and thirteen validated items. Findings indicate that 28% of students experience high technostress levels, while 5% report very high levels, though no significant associations were found between technostress and sociodemographic variables such as campus location, employment status, gender, and academic level. The TS4US instrument had been previously validated in Chile; this study confirms its structure in a new sociocultural context, reinforcing its cross-cultural applicability. These results highlight the need for sustainable strategies to mitigate technostress in higher education, including institutional support, digital literacy programs, and policies fostering a balanced technological environment. Addressing technostress is essential for promoting sustainable education (SDG4) and enhancing student well-being (SDG3). This study directly contributes to the achievement of Sustainable Development Goals 3 (Good Health and Well-being) and 4 (Quality Education) by providing validated tools and evidence-based recommendations to promote mental health and equitable access to digital education in Latin America. Future research should explore cross-country comparisons and targeted interventions, including digital well-being initiatives and adaptive learning strategies, to ensure a resilient and sustainable academic ecosystem.

Keywords: mental health; cyberpsychology; information overload; personal needs; organizational resources; technological resources; socio-technical environment; higher education; students; confirmatory factor analysis



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1. Introduction

Following the COVID-19 pandemic, all aspects of human existence have been profoundly affected, with significant changes in the dynamics of social interaction due to isolation measures. These transformations have left a lasting impact on various social activities, including education, work, and commerce. This shift has notably influenced the concerns and approaches associated with Sustainable Development Goal 3 (SDG 3), which focuses on health and well-being [1].

Globally, digital transformation has become an accelerated necessity, particularly impacting the field of education. The increasing reliance on technology in education has enhanced connectivity and accessibility, but it has also introduced new challenges related to mental well-being and workload for both students and teachers [2].

In addition, in Latin America, the rapid digitalization process has highlighted pre-existing inequalities, especially in terms of internet access, technological infrastructure, and teacher training. Despite progress in the integration of technologies into teaching, challenges remain in ensuring equitable access to digital education [3–5].

Technostress has emerged as a significant consequence of educational digitalization. This phenomenon impacts mental health, productivity, and academic motivation, posing a serious obstacle to the sustainability of digital learning [6–8]. Factors such as technological overload, the intrusion of technology into personal life, and the complexity of digital tools have been identified as key triggers of this issue [9–11].

In this context, Latin America faces an additional challenge: the unequal implementation of technologies in education has created substantial gaps between countries and even within them, particularly affecting rural communities and low-income students. Furthermore, the lack of digital well-being policies and technological literacy strategies has exacerbated the negative effects of technostress in the educational sector [12].

Within the Latin American context, Peru represents a relevant case study due to its combination of socioeconomic disparities, accelerated digitalization without adequate infrastructure support, and a pronounced urban–rural digital divide. The COVID-19 pandemic exposed the lack of institutional preparedness for remote education, increasing the workload for both teachers and students and negatively impacting the quality of learning [13].

Remote education became the primary alternative to ensure the continuity of learning [14,15]. However, not all institutions were prepared for this transition, which exposed technological disparities and highlighted the need for structured induction programs for both students and teachers [16–19]. The increased workload for educators, along with the pressing need to enhance digital competencies and emotional resilience, underscores the importance of developing sustainable educational frameworks [20–22].

Peru is also characterized by a lack of investment in digital infrastructure within the education sector. Unlike other countries in the region that have developed more robust digital policies, education in Peru has faced significant limitations in terms of connectivity, availability of devices, and digital training for both teachers and students [23].

This scenario highlights the urgent need to investigate the impact of technostress on Peruvian university students and to propose strategies that contribute to the sustainability of digital education in the country. It also underscores the urgent need to align educational and technological policies with sustainability principles, particularly in the pursuit of SDGs 3 and 4, which emphasize mental health and equitable access to quality education.

This study adopts a conceptual definition of technostress based on the stress induced by the demands imposed by the use of information and communication technologies (ICT), rather than by their mere presence or usage. This distinction clarifies the construct and aligns it with person–environment fit theory. Furthermore, although “information overload”

is not directly operationalized in the TS4US scale, it is considered a foundational cognitive mechanism underlying technostress. Information overload describes the saturation of digital stimuli that exceed an individual's processing capacity, leading to mental fatigue and impaired decision-making.

The present study addresses this issue and seeks to generate knowledge that is applicable not only within the Peruvian context but also as a foundation for other Latin American countries facing similar challenges. Given these conditions, it is essential to assess technostress using validated tools adapted to the regional context. The Technostress Scale for University Students (TS4US), previously validated in Chile, provides a robust measurement framework.

This study applies confirmatory factor analysis (CFA) to evaluate the psychometric structure of the TS4US scale in Peru, previously validated in Chile, thus testing its robustness in a new sociocultural context. By confirming its factorial validity, the study provides evidence of the instrument's cross-cultural applicability in Latin America. These findings contribute to a deeper understanding of technostress among Peruvian university students and inform sustainable strategies aligned with SDGs 3 and 4. Moreover, the results offer valuable insights for digital education policies and institutional planning in similar regional settings.

2. Literature Review

2.1. Education and Digital Transformation in Times of Crisis

The pandemic accelerated the adoption of remote teaching, establishing it as the immediate solution to ensure the continuity of the educational process [14,15]. However, this transition revealed multiple limitations, particularly in terms of technological infrastructure, teacher training, and digital equity [16].

The unequal access to devices and internet connectivity reflected pre-existing socioeconomic disparities, particularly affecting low-income students. Likewise, the lack of adequate preparation among both teachers and students negatively impacted the effectiveness of remote teaching [17–19]. As a result, teachers experienced a considerable increase in workload, as they not only had to adapt to new technological tools but were also compelled to redesign their pedagogical methodologies [20,21].

Another key factor in the digital transformation of education is technological literacy. In many countries, both teachers and students faced difficulties in adapting to digital platforms due to a lack of training in technological tools. This deficit resulted in a steep learning curve, which negatively affected the quality of the teaching–learning process [24].

Moreover, digital fatigue and mental exhaustion became collateral effects of overexposure to screens, hyperconnectivity, and the lack of adequate spaces for studying or teaching. Research has shown that excessive time spent on digital platforms can negatively impact concentration, productivity, and the mental health of both students and teachers [22].

To move toward a more equitable and sustainable education system, it is essential to strengthen the development of digital competencies among both students and teachers. This would help close the digital divide and reduce the negative effects of technostress [22]. In addition, digital well-being strategies must be established to promote a balance between the use of technology and the physical and mental well-being of educational stakeholders [24].

2.2. Technostress: Definition, Causes, and Contributing Factors

Technostress is defined as the stress generated by the intensive use of information and communication technologies (ICT), affecting both mental health and academic or work performance [25–29]. As ICT has become essential in education and the workplace, technostress has emerged as a growing issue that impacts individuals' productivity, moti-

vation, and overall well-being. It is specifically defined as the stress caused by the demands imposed by the use of ICT [30,31].

More precisely, technostress refers to the psychological strain caused not merely by the presence of ICT but by the demands these technologies impose on users, demands that may exceed individuals' cognitive or emotional coping capacities [30,31]. One of the primary mechanisms underlying technostress is information overload, which occurs when the volume or complexity of digital information surpasses the user's ability to process it efficiently. This overload leads to mental fatigue, anxiety, and reduced academic performance [31–33]. Although not directly operationalized in the TS4US scale, information overload constitutes a foundational experience that underpins the development of technostress symptoms. Given the evident rise in these demands today, numerous studies have been conducted to understand and measure this social phenomenon [34,35]. These investigations have concluded that technostress, particularly among university professors, creates an unfavorable scenario in which their motivation decreases if they do not receive adequate institutional support [35–37] or do not feel empowered or confident in their use of technology. This leads to technostress, which in turn negatively affects their intention to continue in their teaching roles [38–40].

Considering that technostress has not yet reached a balance between the personal resources available for the proper use of ICT and the technological demands placed on individuals, it often leads to negative thoughts and attitudes toward technology, thereby widening the gap between users and technological tools [41]. This is evidenced in manifestations such as techno-anxiety and techno-fatigue, which present through symptoms like anxiety, exhaustion, inefficiency, and skepticism. These findings suggest that technostressors should be regarded as stress factors or conditions that emerge from the interaction between employees and the organizations they belong to, generating tensions within that relationship [42–45] (See Table 1).

Table 1. Creators of technostress.

Precursors	Definition
Techno-overload	Processing information simultaneously with the use of ICT
Techno-invasion	Invasion of technology in the private sphere
Techno-complexity	Availability of time for ICT learning
Techno-insecurity	Constant threat to job position from technology
Techno-uncertainty	Permanent changes due to technological development that affect the learning curve

These factors not only affect the academic sphere but also have consequences for mental health, reinforcing the need for institutional policies aimed at mitigating their impact [39–41]. Research has indicated that the presence of such stressors can increase anxiety, mental fatigue, and lack of motivation among university students, negatively affecting their academic performance and their ability to adapt to new digital environments [42].

The impact of technostress is particularly evident among teachers, who have been required to integrate digital tools into their teaching without adequate preparation. The combination of administrative workload, the need to learn new technologies, and the responsibility of providing emotional support to students has contributed to teacher burnout, which, in the long term, may affect the overall quality of education [43].

Institutions have attempted to address this issue through intervention strategies focused on digital training, psychological well-being, and time management in virtual environments. Training in digital competencies enables students and teachers to become familiar with technological tools, reducing the perceived complexity and the anxiety associ-

ated with learning new platforms. Likewise, regulating screen time and promoting active breaks have been recommended measures to minimize digital fatigue and improve mental well-being [44].

Another key aspect is the development of psychosocial support programs within educational institutions. The creation of psychological counseling spaces and stress management workshops can help students better cope with the pressure resulting from the constant use of ICT in their academic training. Furthermore, the implementation of hybrid teaching methodologies, combining digital tools with in-person activities, could help reduce technological overload and enhance social interaction within the educational environment [45].

As digital education continues to evolve, it is crucial for institutions to implement sustainable strategies aimed at minimizing the negative effects of technostress and ensuring that technology functions as a supportive tool rather than an additional source of anxiety [46–49].

The combination of these factors leads to technostress, which, as previously mentioned, has effects across various levels and domains, including work, family life, and health [33,50]. These factors are associated with the overload of assigned tasks, interactions with peers and leaders, organizational culture, professional trajectory within the institution, and work–life balance. When combined with the use of technology, they create a “cocktail” that impacts employees’ emotions and well-being, an issue that must be acknowledged [33]. However, it is important to note that techno-stressors can have both direct and indirect effects, and the way they manifest in individuals depends on their ability to cope with and manage the problem [51].

In the educational context, technostress among teachers is primarily related to the introduction and adaptation to technology [52]. In this regard, it is essential to recognize that teachers are key actors in the teaching process, and their mental state influences both student performance and the overall work environment they are part of [53–55]. Considering the teacher’s role in relation to their students, their health and well-being can affect levels of anxiety, absenteeism, and depression. In turn, this may negatively impact students’ academic performance as a consequence [56].

From a labor perspective, the use of ICT has contributed to the emergence of technostress [28]. In this context, the objective of this study is to assess the levels of technostress among university students in Lima, with the aim of providing relevant information to support decision-making by university authorities.

3. Study Objectives, Research Question, and Hypotheses

This research aims to understand the factors associated with technostress in higher education contexts within a scenario marked by the accelerated digitalization of educational processes. The widespread incorporation of information and communication technologies (ICT) has brought not only opportunities but also significant challenges for both students and teachers. One of the most notable emerging effects has been the rise of technostress, understood as a specific form of stress that arises when perceived technological demands exceed the personal or institutional resources available. This phenomenon directly impacts student well-being, motivation to learn, and potentially the overall quality of the educational process.

As previously discussed in the literature review, the process of digital transformation in Latin America has been shaped by structural inequalities, including limited internet access, low availability of devices, and insufficient technological training in many educational sectors. These gaps are evident not only between countries but also within them, particularly between urban and rural areas, as well as between public and private institutions.

Despite advances in digital policy in some countries, the region as a whole continues to face significant challenges in ensuring equitable and sustainable digital education. Moreover, the lack of digital well-being programs and technological literacy strategies has exacerbated the negative effects of technostress, impacting mental health, academic motivation, and the performance of both students and teachers. Within this regional context, Peru represents a particularly relevant case due to its pronounced urban–rural digital divide, accelerated digitalization without sufficient infrastructure, and limited institutional response during the health emergency. The pandemic exposed the shortcomings of the national education system in terms of connectivity, training, and emotional support, increasing the workload and psychological distress experienced by both students and teachers. Thus, the research question guiding this study is as follows: What is the level of technostress among university students in Lima, and how is it related to their personal capacities and their perception of institutional support in the context of digital education?

This question arises from a systematic review of recent literature, which highlights technostress as a significant barrier to sustainable learning, particularly when there is a disconnect between technological demands, personal capacities, and institutional support [24,43,47]. As a result, the need was identified for empirical studies that validate specific instruments and analyze the factors associated with technostress from a contextualized perspective.

Based on this literature analysis, the following specific objectives are proposed. First, this study aims to psychometrically validate the TS4US scale within the context of Peruvian higher education, ensuring its reliability and factorial structure through confirmatory factor analysis, as recommended by previous studies conducted in Chile [57]. Second, the study seeks to identify the latent factors that explain technostress, particularly those related to the Socio-Technical Environment (STE) and the perception of institutional support, conceptualized as Needs–Supplies Resources (NSR), two dimensions commonly found in recent models of technological stress in education. Third, it intends to analyze the relationship between levels of technostress and sociodemographic variables such as gender, level of study, and employment status, variables that the literature has identified as potentially associated with digital stress [42]. Finally, the study aims to examine the influence of personal capacities and perceived institutional support on levels of technostress in order to generate evidence that can inform educational sustainability policies aligned with Sustainable Development Goals (SDGs 3 and 4).

In alignment with these objectives, and based on previous theoretical frameworks regarding the interaction between individuals and technological environments [33,58], the following general hypothesis is proposed:

H₀: There is no significant relationship between perceived institutional support and personal capacities (NSR and STE factors) and levels of technostress among university students in Lima.

H₁: Perceived institutional support and personal capacities (NSR and STE factors) are significantly related to levels of technostress among university students in Lima.

Additionally, two specific hypotheses are defined, grounded in empirical evidence that has demonstrated the key role of digital literacy and academic–work conditions in the emergence of technostress [38,44,48]

H_{0b}: Lack of digital literacy does not influence the perception of technostress among university students.

H_{1b}: Lack of digital literacy increases the perception of technostress among university students.

H_{0c}: There are no significant differences in technostress levels between students with and without academic and work responsibilities.

H_{1c}: Students with greater academic and work responsibilities experience higher levels of technostress compared to those without employment.

4. Materials and Methods

A measurement of technostress in university students in Lima was performed based on the Chilean questionnaire TS4US [57], adapted version of the Spanish instrument [58]. The instrument was analyzed for its cultural understanding by two researchers of the team residing in Lima to evaluate its contextual comprehension and applied to students from 4 campuses of a private university located in the city of Lima, representative of the socioeconomic reality in the Peruvian capital. These campuses are strategically distributed across distinct geographic zones, Lima Centro, Lima Norte, and Cono Este, each reflecting diverse socioeconomic realities of the Peruvian capital. Lima Centro includes more consolidated urban areas with greater infrastructure and services, while Lima Norte and Cono Este include middle- and low-income populations, often with more restricted access to digital tools and educational support. Therefore, although the study is based on a single institution, the sample captures relevant variation in students' technological experiences and access to resources within Lima's structurally segmented urban context. A non-probabilistic convenience sampling strategy was applied to reach university students from diverse campuses and academic levels. The 5-point Likert scale was applied: Strongly Disagree = 1, Disagree = 2, Neither Disagree nor Agree = 3, Agree = 4, and Strongly Agree = 5. The questionnaire was administered online using Google Forms, ensuring informed consent, anonymity, and voluntary participation, in line with ethical standards for research involving human subjects. The survey design ensured that no personally or potentially identifiable data could be collected.

Using SPSS version 23 software, the 19 items of the TS4US were analyzed by evaluating their psychometric properties [59]. As a first step, a univariate descriptive statistical analysis was applied, with emphasis on variance, skewness, and kurtosis. Confirmatory factor analyses (CFA) were developed with FACTOR software (Rovira i Virgili University, Tarragona, Version 12.01.02) [60], using Hull's method, revising the Measure of Sampling Adequacy (MSA), which evaluates the suitability of each item to be included in factor analysis. Items with MSA values lower than 0.5 were excluded, as they did not meet the minimum threshold for inclusion [61], and a number of factors were selected that included high communalities and high factor loadings commensurate with the sample size and a minimum number of items per factor (MIF) [62–64]. The indicators are detailed in Table 2 [65].

Chi-square ratio/degree of freedom (χ^2/df), root mean square error of approximation (RMSEA), adjusted goodness-of-fit index (AGFI), goodness-of-fit index (GFI), comparative fit index (CFI), non-normed fit index (NNFI), and root mean square root of residuals (RMSR) [66] were used. The internal consistency of the TS4US scale and its factor structure was assessed using Cronbach's alpha coefficient, with values above 0.80 considered to indicate good reliability in accordance with accepted psychometric standards. The decision to retain two latent factors instead of the original three (PPF, ADTE, and NSR) was guided by empirical fit indices and theoretical interpretability. The third factor could not be sustained due to the loss of key items and the violation of the minimum items per factor (MIF) criterion, which recommends at least three well-performing items per construct for factorial validity.

Table 2. Validation and reliability parameters.

Sample	Method	MIF	χ^2/df	RMSEA	AGFI	GFI	CFI	NNFI	RMSR
≥ 200	Good fit	NR	≥ 0 ≤ 2	≤ 0.05	≥ 0.90 ≤ 1.00	≥ 0.95 ≤ 1.00	≥ 0.97 ≤ 1.00	≥ 0.97 ≤ 1.00	< 0.05 ++
	Acceptable fit	≥ 3	> 2 ≤ 3	> 0.05 ≤ 0.08	≥ 0.85 < 0.90	≥ 0.90 < 0.95	≥ 0.95 < 0.97	≥ 0.95 < 0.97	≥ 0.05 ≤ 0.08 ++

NR: not reported. ++: Kalkan et al. [67].

The weighted technostress levels, given the latent factors resulting from the evaluation of the students, were analyzed by means of cross-tabulations between technostress and the variables—campus, employment status, gender, and level of studies (undergraduate)—using Kendall’s tau-c and Goodman–Kruskal’s gamma tests to measure their symmetrical association [68,69].

5. Results

The TS4US with 3 factors and 19 variables was initially applied on a sample of 328 university students from Lima, meeting the criterion of $n \geq 200$ (Data available in the Supplementary Materials item). This was reduced to 17 variables following the result of the measure of sampling adequacy (MSA), with the exclusion of items V2 and V3, which did not meet the minimum MSA threshold of 0.5.

In addition, the settling of factors and the reordering of variables reconfigured the Abilities–Demands Techno-Educational (ADTE) factors with six items, Needs–Supplies Resources (NSR) with four items, and Person–People Factor (PPF) with only two factors. Thus, the minimum items per factor (MIF) criterion prevented the adoption of the original three factors.

Then, the test with two factors resulted in the loss of another variable (V1 and V14). Recalibrating the model with 15 variables eliminated another variable (V12), while recalibrating the model with 14 variables eliminated another variable (V4). Finally, recalibrating the model with 13 variables did not generate a loss of more variables (see Table 3). The best-fit model retained 13 variables and exhibited excellent psychometric properties, with Cronbach’s alpha = 0.862 and all fit indices meeting or exceeding the required thresholds.

Table 3. Adjusted models and cut-off values.

Model/	Cronbach’s Alpha	χ^2/df *	RMSEA	AGFI	GFI	CFI	NNFI	RMSR	Level Fit
Cut-off	≥ 0.70	≥ 0		≥ 0.90	≥ 0.95	≥ 0.97	≥ 0.97		
	≤ 0.90	≤ 2	≤ 0.05	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	< 0.05 ++	Good
		> 2 ≤ 3	> 0.05 ≤ 0.08	≥ 0.85 < 0.90	≥ 0.90 < 0.95	≥ 0.95 < 0.97	≥ 0.95 < 0.97	≥ 0.05 ≤ 0.08 ++	Acceptable
2F-17V	0.881 ***	1.289 ***	0.030 ***	0.975 ***	0.981 ***	0.994 ***	0.993 ***	0.0590 **	
2F-16V	0.882 ***	1.352 ***	0.033 ***	0.976 ***	0.982 ***	0.994 ***	0.992 ***	0.0597 **	
2F-15V	0.875 ***	1.288 ***	0.030 ***	0.978 ***	0.984 ***	0.995 ***	0.993 ***	0.0567 **	
2F-14F	0.867 ***	1.160 ***	0.022 ***	0.982 ***	0.987 ***	0.997 ***	0.996 ***	0.0516 **	
2F-13V	0.862 ***	1.115 ***	0.019 ***	0.984 ***	0.989 ***	0.998 ***	0.997 ***	0.0495 ***	

++: Kalkan et al. [67]. *: Robust mean and variance-adjusted chi square [70] **: Good fit; *** acceptable fit.

Table 4 presents the 2-factor rotated matrix with 13 variables for TS4US (TS4US-13).

Table 4. Rotated factor matrix.

Variable	F1	F2	Questions (In Spanish/English)	Original Factor	New Factor
V5		0.775	Mi universidad no me brinda suficiente inducción para usar las tecnologías de información de manera efectiva en mis actividades académicas/My university does not provide me with sufficient induction to use information technology effectively in my academic activities.	NSR	NSR
V6		0.676	Mi universidad no me brinda incentivos suficientes para utilizar las tecnologías de información de manera efectiva en mis actividades como estudiante/My university does not provide me with sufficient incentives to use information technology effectively in my student activities.	NSR	NSR
V7		0.507	La inducción desarrollada por mi universidad no es muy útil para lograr un uso efectivo de las tecnologías de información/The induction developed by my university is not very useful to achieve an effective use of information technologies.	NSR	NSR
V8		0.478	En mi universidad no existe una cultura que fomente el uso de herramientas innovadoras como las tecnologías de información/In my university there is no culture that encourages the use of innovative tools such as information technology.	NSR	NSR
V9	0.505		Me resulta difícil utilizar las tecnologías de información de manera efectiva debido al poco tiempo y esfuerzo que le dedico/I find it difficult to use information technology effectively because of the little time and effort I put into it.	ADTE	STE
V10	0.742		Me resulta difícil hacer frente a las altas demandas de las tecnologías de información con mi capacidad actual/I find it difficult to cope with the high demands of information technology with my current capacity.	ADTE	STE
V11	0.835		Me resulta difícil ponerme al día con los rápidos cambios de las tecnologías de información/I find it difficult to keep up with the rapid changes in information technology.	ADTE	STE
V13	0.741		Las tecnologías de información en mi universidad no son muy importantes/Information technologies at my university are not very important.	NSR	STE
V15	0.488		Las diversas tecnologías de información complican mi proceso de toma de decisiones académicas/Diverse information technologies complicate my academic decision-making process.	ADTE	STE
V16	0.502		Me molesta el uso excesivo de las tecnologías de información en mi universidad/I resent the excessive use of information technology at my university.	ADTE	STE
V17	0.692		No tengo el apoyo suficiente de mis compañeros para el uso de las tecnologías de información/I do not have sufficient support from my colleagues for the use of information technologies.	PPF	STE
V18	0.541		Mis compañeros no son positivos con respecto al uso innovador de las tecnologías de información en mi universidad/My peers are not positive about the innovative use of information technology at my university.	PPF	STE
V19	0.476		No tengo un equipo con el que colaborar para encontrar una forma eficaz de usar las tecnologías de información en mis actividades como estudiante universitario/I do not have a team to collaborate with to find an effective way to use information technology in my activities as a university student.	PPF	STE
Eigenvalue	5.34587	1.22046			
Proportion of variance	0.41122	0.09388			
Cumulative proportion of variance	0.41122	0.50510			

Table 4 shows that Factor 2, Needs–Supplies Resources (NSR), is supported by four items that account for the student’s perception of the support provided by their university. The other factor integrates items that originally represented the latency of Abilities–Demands Techno-Educational (ADTE) with five items, Person–People Factor (PPF) with three items, and even an item belonging to Needs–Supplies Resources (NSR). All in all, Factor 1 reflects the student’s relationship and skills to perform in a Socio-Technical Environment (STE).

$$\text{So, } F1 = \text{RND} (\text{MEAN}(V09,V10,V11,V13,V15,V16,V17,V18,V19)),$$

$$\text{and } F2 = \text{RND} (\text{MEAN}(V05,V06,V07,V08)).$$

$$\text{Then, } TS = \text{RND} ((5.34587 \times F1 + 1.22046 \times F2)/(5.34587 + 1.22046)).$$

Depending on the resulting construct, different levels of technostress were established for the analyzed group of university students in Lima, as shown descriptively in Table 5 and at the percentile level in Table 6.

Table 5. Descriptive statistics of the measured technostress.

Technostress		Statistic	Standard Error
Mean		3.02	0.053
95% confidence interval for the mean	Lower limit	2.91	
	Upper limit	3.12	
Median		3.00	
Variance		0.939	
Standard deviation		0.969	
Skewness		0.051	0.135
Kurtosis		−0.674	0.268

Table 6. Percentiles of technostress measured.

Technostress	Percentiles						
	5	10	25	50	75	90	95
Weighted average	2.00	2.00	2.00	3.00	4.00	4.00	5.00
Tukey hinges			2.00	3.00	4.00		

Table 6 reflects a set of cases in the 75th percentile and above that present high levels of technostress, as also shown in the histogram in Figure 1.

To recognize the causes of the high levels of technostress in 109 students, cross-tables were constructed between technostress and campus, employment status, gender, and level of study. The Kendall’s gamma and tau-c tests showed that there is no association between technostress and these variables (see Appendix A).

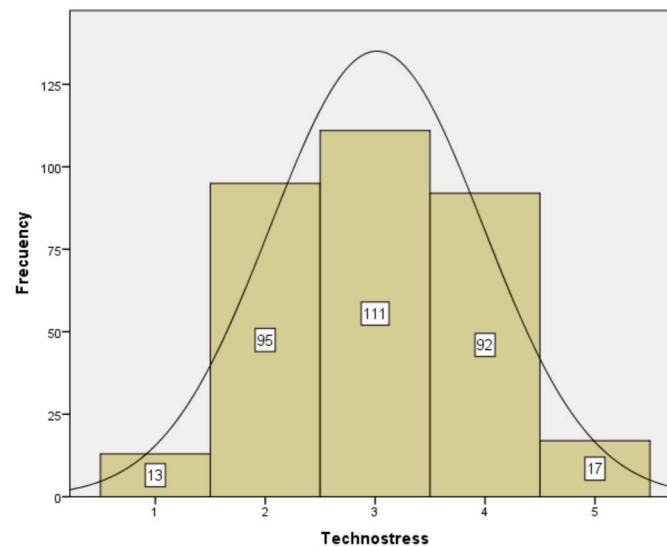


Figure 1. Histogram of measured technostress.

6. Discussion

This study employed a measurement instrument originally designed to assess technostress in higher education in China [54] and later recalibrated for university students in Spain [58] and Chile [57]. In the Peruvian context, confirmatory factor analysis (CFA) led to the refinement of the original 3-factor, 19-variable structure (TS4US) into a more parsimonious and theoretically consistent model with 2 factors and 13 variables (TS4US-13). The first factor, Needs–Supplies Resources (NSR), was retained from the original structure, while the second, Socio-Technical Environment (STE), emerged by combining and reorganizing variables from the Person–People Factor (PPF) and the Abilities–Demands Techno-Educational (ADTE) constructs.

The NSR factor captures the alignment, or misalignment, between students’ personal needs and the technological and organizational resources available to them, including the availability, usability, and perceived usefulness of ICT tools. This finding is consistent with earlier studies that conceptualize adequate resource provision as a buffer against technostress [33,57,71,72]. In line with the general hypothesis (H_1), our results confirm that the perception of institutional support plays a significant role in determining technostress levels.

The second factor, STE, is conceptually broader than the original dimensions but remains consistent with theoretical models such as the Job Demands–Resources framework and the person–environment fit theory. This factor includes elements of social support and peer learning (PPF) [73–75] as well as the tensions between personal abilities and external demands, both organizational (ADO) and technological (ADT) [57,58]. These tensions give rise to technostress through mechanisms such as (1) dissonance between task requirements and personal capabilities [76–79], (2) ICT overload due to institutional inefficiencies [31,47,80], and (3) insufficient resources to meet high digital demands [41,71].

The empirical data revealed that 28% of students experienced high levels of technostress, and 5% reported very high levels, signaling a widespread issue across the sample. Interestingly, and in support of hypothesis H_{0c} , no significant differences were observed in technostress levels across gender, employment status, campus, or academic level. This suggests that technostress is not limited to particular subgroups but rather reflects institutional-level digital education challenges observed in the case analyzed.

Regarding hypothesis H_{1b} , the structure of the STE factor suggests that digital literacy gaps, though not directly measured, play a key role in technostress. The presence of

items reflecting students' inability to meet technological demands implies that insufficient digital competence is a contributing factor. This supports H_{1b} , aligning with literature that identifies digital literacy as a protective factor against technostress [31,41,57]. Although digital literacy was not included as an explicit variable in the instrument, its impact is indirectly captured through the latent construct Socio-Technical Environment (STE). This factor comprises items related to perceived overload, difficulty in adapting to technological change, low confidence in digital environments, and lack of peer support, all dimensions that the literature associates with limited digital competencies. As is common in latent factor models, such indirect relationships reflect the influence of unobserved traits through observable indicators. This clarification strengthens the interpretation of H_{1b} and supports the need to address digital skills as part of institutional interventions.

However, hypothesis H_{1c} , which proposed that students with greater academic and employment responsibilities experience higher technostress, was not supported by the findings. The absence of significant differences by employment status or academic workload suggests that these stressors are distributed across the student body, possibly due to the uniform demands imposed by digital platforms and institutional systems.

This unexpected null result may indicate that the digital demands of institutional platforms and virtual environments affect students uniformly, regardless of their employment status. From the perspective of person–environment fit theory, it is possible that organizational demands exceed the coping capacities of students across various sociodemographic profiles, diminishing the expected impact of employment as an additional stressor.

These findings carry important implications for educational management. Despite the evident prevalence of technostress, few Latin American institutions have developed coping protocols or preventive policies [81,82]. The lack of structured responses places students at risk and limits their ability to adapt to increasingly digital learning environments. Institutional strategies must therefore address both the material conditions (e.g., access and infrastructure) and the psychosocial environment (e.g., training and support networks) that modulate stress levels.

Moreover, this research highlights the need to expand the scope of technostress studies toward emerging challenges in digital education, such as techno-addiction [83,84], cyberbullying [85], and students' technology readiness and acceptance [86,87]. Future investigations should explore how technostress interacts with these phenomena and assess the impact of preventive strategies on student well-being and academic success.

Ultimately, the findings underscore that addressing technostress is not only essential for improving academic performance but also for promoting student health and emotional resilience, contributing directly to Sustainable Development Goals 3 (Good Health and Well-being) and 4 (Quality Education) [88].

7. Conclusions

This study establishes the validity and reliability of the TS4US-13 scale to measure technostress in Peruvian university students. The refined two-factor structure, comprising Needs–Supplies Resources (NSR) and Socio-Technical Environment (STE), proved to be theoretically coherent and statistically robust for the Latin American context.

Empirical evidence indicates that approximately one-third of students report high or very high levels of technostress. Crucially, these levels are not associated with sociodemographic variables such as gender, academic level, campus, or employment status, thereby supporting H_{0c} . This suggests that technostress is not limited to particular subgroups but rather reflects institutional-level digital education challenges observed in the case analyzed.

The findings confirm the general hypothesis H_1 and the specific hypothesis H_{1b} , showing that both institutional support and students' personal digital capacities are significantly

associated with technostress. These dimensions should be considered central when designing interventions to reduce digital stress and improve the quality of student experiences.

From a practical perspective, these results highlight the need for preventive and corrective actions by university authorities. Institutions must not only guarantee access to functional and relevant technological tools but also offer training in digital competencies, promote emotional resilience, and reinforce support networks to reduce the psychological overload associated with digital education. Moreover, the findings indirectly reflect the role of digital literacy in modulating technostress, suggesting that strengthening students' digital skills should be a core component of institutional strategies to foster sustainable learning environments.

Despite these contributions, the study is not without limitations. First, its cross-sectional design precludes causal inferences, limiting the ability to determine whether the identified factors are antecedents or consequences of technostress. Second, the reliance on self-report instruments may introduce bias due to social desirability or subjective interpretation. Third, the study was conducted within a single private university in Lima, which, although encompassing students from multiple urban zones with varied socioeconomic backgrounds, still restricts generalizability to other institutional types (e.g., public universities and rural institutions) or national contexts. Fourth, the model did not incorporate other potentially relevant variables, such as prior exposure to digital tools, personality traits (e.g., neuroticism), or coping styles, which could influence technostress levels. Finally, qualitative perspectives were not included, which might have enriched the understanding of students' lived experiences in navigating digital learning environments.

Future research should adopt longitudinal and mixed-methods designs to explore the evolution of technostress over time and uncover qualitative dimensions not captured by quantitative instruments. Moreover, future studies should examine how technostress interacts with academic performance, motivation, dropout intentions, and other psychological variables such as burnout or anxiety. Such investigations would further strengthen the alignment of higher education research with Sustainable Development Goal targets 3.4 and 4.4 by generating evidence to support mental health promotion and the development of digital competencies among university students.

In summary, this research provides a validated instrument, empirical evidence, and theoretical insights that contribute to understanding and managing technostress in Latin American higher education. It lays a foundation for both academic inquiry and institutional innovation aimed at promoting educational sustainability and psychological well-being in increasingly digital learning environments.

Supplementary Materials: The following supporting information can be downloaded at <https://doi.org/10.5281/zenodo.8295199> (accessed on 27 June 2025), Table S1: DATA_TS4US_PE.sav (file for SPSS software).

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Appendix A

Cross-tabulations are presented between technostress and campus, employment status, gender, and level of studies (undergraduate), reporting Kendall's tau-c and Goodman–Kruskal's gamma tests for each variable crossing with technostress. Both tests reach their highest levels of association at ± 1 values.

Table A1. Campus $\times$ technostress.

			Technostress					Total
			1	2	3	4	5	
Campus	Villa	Count	2 _a	12 _a	17 _a	12 _a	4 _a	47
		Expected count	1.9	13.6	15.9	13.2	2.4	47.0
	San_Miguel	Count	3 _a	27 _a	19 _a	16 _a	3 _a	68
		Expected count	2.7	19.7	23.0	19.1	3.5	68.0
	San_Isidro	Count	2 _a	18 _a	27 _a	24 _a	3 _a	74
		Expected count	2.9	21.4	25.0	20.8	3.8	74.0
	Monterrico	Count	6 _a	38 _a	48 _a	40 _a	7 _a	139
		Expected count	5.5	40.3	47.0	39.0	7.2	139.0
	Total	Count	13	95	111	92	17	328
		Expected count	13.0	95.0	111.0	92.0	17.0	328.0

Each letter of the subscript denotes a subset of technostress categories whose column proportions do not differ significantly from each other at the 0.05 level.

Symmetric measures					
		Value	Asymptotic standard error ^a	Approximate T ^b	Approximate significance
Ordinal per ordinal	Tau-c de Kendall	−0.023	0.045	−0.501	0.616
	Gamma	−0.033	0.067	−0.501	0.616
No. of valid cases		328			

a. The null hypothesis is not assumed. b. Use of the asymptotic standard error that presupposes the null hypothesis.

Table A2. Employment $\times$ technostress.

			Technostress					Total
			1	2	3	4	5	
Employment	Not interested for now	Count	0 _a	1 _a	5 _a	3 _a	1 _a	10
		Expected count	0.4	2.9	3.4	2.8	0.5	10.0
	Working	Count	4 _a	22 _a	21 _a	28 _a	2 _a	77
		Expected count	3.1	22.3	26.1	21.6	4.0	77.0
	Exclusively studying	Count	4 _a	47 _a	46 _a	32 _a	6 _a	135
		Expected count	5.4	39.1	45.7	37.9	7.0	135.0
	Unemployed	Count	2 _a	6 _a	14 _a	8 _a	2 _a	32
		Expected count	1.3	9.3	10.8	9.0	1.7	32.0
	Physical or mental disability	Count	1 _a	1 _a	1 _a	0 _a	0 _a	3
		Expected count	0.1	0.9	1.0	0.8	0.2	3.0
	Searching for the first time	Count	2 _a	18 _a	24 _a	21 _a	6 _a	71
		Expected count	2.8	20.6	24.0	19.9	3.7	71.0
	Total	Count	13	95	111	92	17	328
		Expected count	13.0	95.0	111.0	92.0	17.0	328.0

Table A2. Cont.

		Technostress					
		1	2	3	4	5	Total
Each letter of the subscript denotes a subset of technostress categories whose column proportions do not differ significantly from each other at the 0.05 level.							
Symmetric measures							
		Value	Asymptotic standard error ^a	Approximate T ^b		Approximate significance	
Ordinal per ordinal	Tau-c de Kendall	−0.009	0.043	−0.218		0.828	
	Gamma	−0.014	0.066	−0.218		0.828	
No. of valid cases		328					

a. The null hypothesis is not assumed. b. Use of the asymptotic standard error that presupposes the null hypothesis.

Table A3. Gender $\times$ technostress.

			Technostress					
			1	2	3	4	5	Total
Gender	Female	Count	9 _a	53 _a	55 _a	54 _a	12 _a	183
		Expected count	7.3	53.0	61.9	51.3	9.5	183.0
	Male	Count	4 _a	42 _a	56 _a	37 _a	4 _a	143
		Expected count	5.7	41.4	48.4	40.1	7.4	143.0
	Prefer not to say	Count	0 _a	0 _a	0 _a	1 _a	1 _a	2
		Expected count	0.1	0.6	0.7	0.6	0.1	2.0
Total	Count	13	95	111	92	17	328	
	Expected count	13.0	95.0	111.0	92.0	17.0	328.0	
Each letter of the subscript denotes a subset of technostress categories whose column proportions do not differ significantly from each other at the 0.05 level.								
Symmetric measures								
			Value	Asymptotic standard error ^a		Approximate T ^b		Approximate significance
Ordinal per ordinal	Tau-c de Kendall		0.015	0.046		0.330		0.741
	Gamma		0.028	0.085		0.330		0.741
No. of valid cases			328					
a. The null hypothesis is not assumed. b. Use of the asymptotic standard error that presupposes the null hypothesis.								

Table A4. Study_level (undergraduate) $\times$ Technostress.

		Technostress						
		1	2	3	4	5	Total	
Study_level	Fifth year or more	Count	4 _a	19 _a	30 _a	29 _a	2 _a	84
		Expected count	3.5	24.2	28.5	23.2	4.6	84.0
	Fourth year	Count	2 _a	18 _a	16 _a	18 _a	3 _a	57
		Expected count	2.4	16.4	19.4	15.7	3.1	57.0
	Third year	Count	2 _a	13 _a	14 _a	7 _a	1 _a	37
		Expected count	1.5	10.7	12.6	10.2	2.0	37.0
	Second Year	Count	4 _a	32 _a	34 _a	28 _a	7 _a	105
		Expected count	4.4	30.3	35.7	28.9	5.7	105.0
	First year	Count	1 _a	8 _a	12 _a	4 _a	4 _a	29
		Expected count	1.2	8.4	9.9	8.0	1.6	29.0
Total	Count	13	90	106	86	17	312	
	Expected count	13.0	90.0	106.0	86.0	17.0	312.0	
Each letter of the subscript denotes a subset of technostress categories whose column proportions do not differ significantly from each other at the 0.05 level.								
Symmetric measures								
		Value	Asymptotic standard error ^a		Approximate T ^b		Approximate significance	
Ordinal per	Tau-c de Kendall	0.024	0.043		0.550		0.582	
ordinal	Gamma	0.035	0.063		0.550		0.582	
	No. of valid cases	312						
a. The null hypothesis is not assumed. b. Use of the asymptotic standard error that presupposes the null hypothesis.								

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