HUMAN-MACHINE INTERACTION AND PSYCHOLOGICAL WELL-BEING IN UNIVERSITY STUDENTS: RESULTS FROM THE PRIN *DIGIWELL* PROJECT

INTERAZIONE UOMO-MACCHINA E BENESSERE PSICOLOGICO NEGLI STUDENTI UNIVERSITARI: RISULTATI DAL PROGETTO PRIN *DIGIWELL*

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ABSTRACT
The DigiWell project explores how digital technology use and technostress affect university students' psychological well-being. Results from the DigiWell project (344 students) show that lower perceived usefulness of technology and higher technostress are associated with greater distress. Gender and age influence students' digital attitudes and distress levels. Findings highlight the importance of promoting digital well-being in higher education.

Il progetto DigiWell esplora come l'uso delle tecnologie digitali e il tecnostress influenzano il benessere psicologico degli studenti universitari. I risultati del progetto (344 studenti) mostrano che una minore utilità percepita delle tecnologie e un più elevato livello di tecnostress sono associati a un maggiore disagio psicologico. Genere ed età influenzano gli atteggiamenti digitali degli studenti e i livelli di distress. I risultati evidenziano l'importanza di promuovere il benessere digitale nell'istruzione superiore.

KEYWORDS
Digital well-being; University students; Psychological distress; Technostress; Propensity to use technology; Higher education; Mental health
Benessere digitale; Studenti universitari; Disagio psicologico; Tecnostress; Propensione all'uso delle tecnologie; Istruzione superiore; Salute mentale

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Introduction

The COVID-19 pandemic has significantly impacted the mental health of university students, contributing to heightened levels of anxiety, stress, and depression across global academic contexts (Cao et al., 2020; Jardon & Choi, 2022; Capone et al., 2020). In response to these challenges, increasing attention has been given to the potential of digital technologies as tools for supporting psychological well-being in higher education settings (Toto & Limone, 2021a; Riva et al., 2020). According to the framework of digital well-being theory, the effects of digital media on individual well-being are not inherently positive or negative, but are mediated by users' engagement patterns, perceived utility, and the broader socio-technical context in which technologies are used (Riva et al., 2020). Within this framework, human-machine interaction becomes an essential domain of investigation, particularly for vulnerable populations such as university students (Ruini et al., 2024).

The PRIN project *DigiWell: Digital Technologies for Promoting Wellbeing in University Students*, that involves three Italian universities (Bologna, Modena-Reggio Emilia e Pegaso) aims to promote the mental health and psychological well-being of Italian university students through psychological interventions delivered via digital technologies, including virtual reality, following a stepped care approach. It also seeks to reduce psychological distress and mental health stigma, and to validate the effectiveness of both online group interventions and individual virtual reality-based interventions within the academic context.

1. Theoretical framework and research aims

This study is situated within the PRIN-funded DigiWell Project, which aims to explore the role of digital technologies in promoting psychological well-being in Italian university students. Drawing on the principles of positive psychology (Keyes, 2002; Ruini, 2017), the project defines well-being not as the mere absence of psychopathology, but as the presence of positive emotions, relationships, and meaning in life. A key construct in this research is the Propensity to Use Technologies (PtUT)**,** which reflects individuals' openness, confidence, and perceived usefulness of digital tools. Previous research has highlighted how digital engagement, when guided by personal needs and competencies, can positively influence well-being (Toto & Limone, 2021b; Riva et al., 2020). This study specifically explores the relationship between PtUT and psychological distress, as

assessed by the Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995; Bottesi et al., 2015), to contribute to the literature on digital health and youth mental health (Ruini et al., 2024).

Another issue to consider is the concept of technostress, a modern term referring to stress caused by prolonged exposure to new ICT such as the internet, mobile phones, laptops, telecommuting and virtual education (Cari Calcina, 2021). Coined by the American psychologist Craig Brod in 1984, this term refers to an adaptation disorder caused by difficulty coping healthily with new information technologies (Chiappetta, 2017). Technostress syndrome can include both physical and psychological symptoms.

Physical health problems may include increased heart rate, cardiovascular disorders such as hypertension, and gastrointestinal disturbances including irritable bowel syndrome, gas, and reflux. Other symptoms are muscle tension and pain, tingling in the limbs, insomnia and disturbances to the sleep-wake rhythm, headaches, chronic fatigue, excessive sweating, neck pain, stress-related skin disorders, and, in women, hormonal and menstrual disorders.

Mental distress may manifest as irritability, depression, behavioural changes, decreased sexual desire, crying spells, sleep disturbances, and apathy (Chiappetta, 2017).

Mental disorders typically emerge in early adulthood, making university students a vulnerable population. Furthermore, the negative impact of the ongoing pandemic on disadvantaged students has exacerbated the existing inequality gap between the academically successful and those who are not (Cordini & De Angelis, 2021; Grewenig et al., 2021; Perry et al., 2021). Researchers are also increasingly interested in the role of technology in enabling or triggering various mental disorders among college students (Lattie et al., 2019), while systematic reviews emphasise the need for targeted treatments and preventive interventions for this vulnerable population (Lynch et al., 2020).

These insights highlight the relevance of integrating digital literacy and emotional self-regulation strategies into mental health initiatives, particularly in academic environments shaped by hybrid and online learning models. The DigiWell framework contributes to shaping evidence-based digital mental health services that are scalable, sustainable, and responsive to the needs of contemporary university students (Ruini et al., 2024).

2. Method

Participants

The study involved 344 university students (75 males; Mage = 29.19) from three different Italian universities and enrolled in healthcare or helping profession courses. Indeed, the students in these courses have shown to be more vulnerable to experiencing psychological distress, particularly anxiety and depression (see Ruini et al., 2023). Moreover, because one of the three universities involved in the study was a digital university, students in the sample come from all over the country.

Measures

Depression, anxiety and stress. The Italian version of Depression Anxiety Stress Scale (DASS-21; Bottesi et al., 2015) was used to measure participants' levels of depression, anxiety and stress. Students were asked to read 21 statement regarding depression (7 items, e.g.: "I couldn't seem to experience any positive feeling at all"), anxiety (7 items, e.g.: "I felt scared without any good reason"), and stress (7 items, e.g.: "I found it difficult to relax") rating how much each statement applies to them on a scale from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). Scores was summed within each subdimension to obtain scores of students'anxiety, depression and stress, and the scores on the three subscales were then summed to obtain an overall score of psychological distress. The Italian validation of the instrument evidenced good psychometric properties. Cronbach's alpha= .86 for anxiety; .89 for depression; .87 for stress; and .94 for the overall score

Propensity to use technologies (PtUT). We adapted the questionnaire used by Al-Adwan et al. (2023) to measure the intention of university students to use metaverse educational platforms, replacing "metaverse educational platforms" with "technologies" and eliminating or modifying the reference to educational context. Our adapted version of the questionnaire included 21 items measuring, just like the original version: Perceived Usefulness (PU; 3 items, e.g.: "technologies enable me to accomplish tasks more quickly") and Perceived Eease of Use (PEU; 4 items, e.g.: "It is easy for me to become skillful at using technologies") of technologies, Self-efficacy (SE; 3 items, e.g.: "I am confident that I can perform effectively on many different tasks"), Perceived Enjoyment (PE; 3 items, e.g.: "Technologies make my leisure time more fun") and Perceived Cyber Risks (PCR; 3 items, e.g.: "Technologies have enough safeguards to make me feel comfortable

using them") in the use of technologies, and Personal innovativeness in IT (PIIT; 4 items, e.g.: "If I heard about a new technology, I would look for ways to experiment with it"). Participants were asked to rate each statement on a scale from 1 (strongly agree) to 5 (strongly disagree), thus high scores mean lower levels of the mentioned dimensions. Cronbach's alpha= .82 for PU; .91 for PEU; .84 for SE; .89 for PE; .78 for PCR; .82 for PIIT.

Technostress (TS). We used the anxiety and ineffectiveness subdimension of the questionnaire about technostress developed by Buenadicha-Mateos and colleagues (2022). Our measure included 6 items evaluating individuals' anxiety (TA; e.g.: "I feel tense and anxious when working with technology.") and sense of ineffectiveness (TI; e.g.: "I'm not sure I'm completing tasks well when using technology") when using technologies. Participants were asked to rate the frequency with which they feel like described by each statement using a scale ranging from 1 (never/almost never) to 5 (always/almost always). Cronbach's alpha=.81 for TA; and .85 for TI.

Procedure

Participants completed the questionnaires online from February to December 2024. Students learned about the DigiWell project and the questionnaire as first step of the protocol, during university course lessons, or from flyers hanging on university noticeboards, or from their university digital dashboard and voluntarily decided to participate. Once they got the link and clicked on it, before starting to complete the questionnaire, participants had to read an informed consent including the description of the complete protocol. Moreover the informed consent informed them that their participation in the study were voluntary; that all their responses were confidential and would have been anonymized; and they could withdraw at any moment. Students had to give their consent to start the questionnaire.

3. Results

Preliminarily, the pattern of relations among the study variables were investigated using Pearson's correlations. Results evidenced that all subdimensions of the PtUT except that PIIT were significantly and positively associated with overall psychological distress (from r=.15, p<.01 to r=.21, p<.001) and depression (from r=.11, p<.05 to r=.20, p<.001), while all subdimensions of the PtUT except that PCR and PIIT were significantly and positively associated with anxiety (from r=.12,

p<.05 to *r*=.18, *p*<.01), and all subdimensions of the PtUT except that SE and PIIT were significantly and positively associated with stress (from *r*=.11, *p*<.05 to *r*=.15, *p*<.01). Moreover, the two subdimensions of technostress were significantly and positively associated with overall psychological distress (TA *r*=.29; TI *r*=.28) and all subdimensions of DASS (from *r*=.23, *p*<.001 to *r*=.29, *p*<.001). Finally, overall psychological distress and all subdimensions of DASS (from *r*=.14, *p*<.01 to *r*=.66, *p*<.001) and the two subdimensions of technostress (*r*=. 69) were significantly and positively associated between each other.

Moreover, gender and age differences were investigated using a Multivariate Analysis of Variance (MANOVA) with gender and age (younger students < 30 years old; elder students= 30 years and older) as independent variables and overall psychological distress, all subdimensions of DASS and the two subdimensions of technostress as dependent variables. Result showed that females were higher on PEU, PIIT, TA and anxiety, while younger students were higher on all subdimensions of PtUT except PEU and on all subdimensions of DASS. Finally, considering the overall measure of psychological distress, younger students showed higher mean scores, while no gender differences emerged (Table 1)

Table 1. Gender and age differences among study variables

	Males (N=75)		***Females (N=269)***		**F**	***Younger students (N=228)***		***Elder students (N=116)***		***F***
	Mean	***sd***	***Mean***	***sd***		***Mean***	***sd***	***Mean***	***sd***	
Propensity to use technologies										
Perceived Usefulness (PU)	2.10	.85	2.14	.86	.00	2.31	.84	1.78	.78	**18.16*** **
Perceived Eease of Use (PEU)	1.89	.70	2.21	.93	**6.51***	2.17	.87	2.07	.94	.51

Self-efficacy (SE)	2.43	.95	2.57	.87	1.07	2.70	.83	2.21	.92	**15.72*** **
Perceived Enjoyment (PE)	2.30	1.05	2.48	1.01	1.71	2.60	.98	2.12	.99	**12.21** **
Perceived Cyber Risks (PCR)	3.13	1.06	3.18	.97	.45	3.33	.92	2.84	1.03	**18.75*** **
Personal innovativeness in IT (PIIT)	2.60	.93	2.99	.90	**8.23** **	3.06	.80	2.61	1.05	**9.41** **
					Psychological distress					
Anxiety	7.47	7.23	10.40	8.77	**6.30***	10.88	8.51	7.53	8.16	**8.34** **
Depression	13.87	11.20	13.47	9.31	.03	15.20	9.97	10.30	8.41	**16.81*** **
Stress	17.17	9.38	19.37	9.23	3.10	20.09	9.32	16.50	8.79	**8.61** **
Overall psychological distress	19.25	12.68	21.62	12.08	2.21	23.08	12.26	17.17	11.24	**14.18*** **
					Tecnostress					
Tecno-anxiety	1.45	.61	1.66	.77	**3.92***	1.66	.72	1.53	.77	1.27
Ineffectiveness	1.53	.68	1.62	.80	.42	1.65	.74	1.49	.84	1.35

Subsequently, in order to test our main hypotheses a series of hierarchical regressions were performed controlling gender and age and including in the second step all subdimensions of DASS except PIIT that demonstrated no significant correlations with psychological distress and in the third step the two subdimensions of technostress. As dependent variables were alternatively

introduced the overall score of psychological distress and the three subdimensions of DASS. Results showed that the overall score of psychological distress was significantly predicted by UP, TA and TI, while, considering the subdimensions of DASS, anxiety was significantly predicted by UP, FA and TA; depression by UP and TI; and stress only by TA (Table 2). All predictors explain the 14% of variance regarding anxiety, 13% of variance regarding depression, 11% of variance regarding stress and 15% of variance regarding the overall psychological distress.

Table 2. Hierarchical regressions

		DASS TOT		***ANXIETY***		***DEPRESSION***		***STRESS***	
Step	***Predictors***	**β**	**ΔR^2**	**β**	**ΔR^2**	**β**	**ΔR^2**	**β**	**ΔR^2**
1	**Gender**	.07	.04**	**.14***	.05***	-	.03**	-	.03**
	Age	**-.20*****		**-.16****		**-.18****		-.18**	
2	**Perceived Usefulness**	**.16***	.05**	**.15***	.04*	**.16***	.06**	.10	.03
	Perceived Eease of Use	.08		**.15***		.01		.08	
	Self-efficacy	-.08		-.08		-.04		-.08	
	Perceived Enjoyment	.05		-.01		.09		.04	
	Perceived Cyber Risks	.08		.03		.09		.09	

3	**Tecno-anxiety**	**.19***	.06***	**.20****	.05***	.13	.04***	**.18***	.05***
	Ineffectiveness	**.15***		.11		**.16***		.14	
		R^2 tot	**.15**		**.14**		**.13**		**.11**

Findings revealed that, overall, in particular students giving less consideration to the usefulness of technology are more exposed to psychological distress, in particular to anxiety and depression. Consistently, technostress, that can be considered an indicator of discomfort in using technologies, gives its contribution as a further risk factor, increasing the possibility that students experience all kinds of psychological distress taken into account.

Conclusions

The data obtained from the preliminary analyses allow us to demonstrate how gender and age influence the propensity to use technologies in terms of self-efficacy and perceived usefulness, as well as a greater inclination toward using new technologies. These results suggest that some dimensions of the propensity to use technologies may serve as protective factors against psychological distress, particularly among women. However, future studies should examine the role of each factor that characterizes the propensity to use technologies, as identified by educational authorities (Adwan et al., 2023). The data also prompt reflection on the concept of digital well-being.

An individual's digital practices can lead to both harms and benefits, which often coexist and influence subjective well-being. These can be moderated by additional variables, such as personality, situation, social networks, and socio-cultural context. While there is nothing inherently harmful or beneficial about digital media, the digitisation of society and everyday life can undoubtedly impact well-being. However, this impact is difficult to assess empirically due to the lack of reliable and valid measures, formal models, and sound theory. The digital well-being framework assists in selecting and specifying plausible pathways between individuals' specific digital practices and well-being-related outcomes. Its scope and generality encourage researchers to select moderators and mediators and

specify the most relevant conditions and intermediate steps relating to digital practices, harm or benefit, and well-being measurement (Büchi, 2024).

A useful theory of digital well-being will be subject to a cycle of identification, development, formalisation and evaluation (Borsboom et al., 2021; Little & Pepinsky, 2016; Van Rooij & Baggio, 2021).

In conclusion, digital media should not be treated as 'pharmaka', i.e. poison, cure and scapegoat. Instead, digital media are increasingly shaping human communication, which is essential for well-being. Their impact is neither predetermined nor non-existent. Aiming for abstraction without oversimplification, the digital well-being framework should consider three crucial interdependencies:

1) Individuals' digital practices depend on the situational and long-term opportunities and constraints offered by their social environment and technological developments.

2) The different manifestations of individuals' digital practices lead to concomitant concrete harms and benefits.

3) The balance and accumulation of these harms and benefits affect overall well-being (Buchi, 2024).

Therefore, continuous conceptual work is needed to integrate individual empirical studies of limited validity and achieve generalised knowledge.

Technostress can erode students’ overall well-being, reducing life satisfaction and contributing to burnout. When managed effectively, however, digital tools can enhance well-being by supporting flexible learning and connection (Cazan et al., 2023). This is why the experimental implementation of the DigiWell project is so important: it aims not only to prevent psychological distress through traditional treatments delivered online, but also to offer innovative therapeutic interventions based on virtual reality.

In terms of implications for university policies, projects like DigiWell outline a replicable intervention model that could be integrated into university psychological support services. Today, universities are called upon to recognize digital well-being as an integral part of academic quality of life, by implementing systemic actions for prevention, emotional-digital literacy, and the promotion of sustainable digital environment.

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