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Protective factors against technostress in secondary school teachers

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Reliance on innovative learning and teaching methodologies based on Information and Communication Technologies (ICTs) is continuously growing in educational institutions. However, using ICTs requires up-to-date knowledge, digital skills, and flexible adaptation to technological changes and challenges. These demands can lead teachers to experience technostress, undermining their ability to cope with emerging technologies and fully exploit their potential. This is particularly true for teachers who lack appropriate emotion regulation strategies and digital proficiency. In the present study, we investigated technostress creators among secondary school teachers, evaluating the predictive role of cognitive emotion regulation and the mediating role of self-efficacy in digital competencies. Notably, adaptive and maladaptive cognitive emotion regulation strategies were distinguished to clarify their distinct contributions to teachers' psychological experience of technostress creators. Mediation analyses highlighted a direct effect of maladaptive strategies on the experience of technostress creators, whereas adaptive strategies exerted an indirect effect through self-efficacy in digital competencies. Maladaptive emotion regulation was positively associated with higher levels of technostress creators, whereas adaptive emotion regulation was positively associated with self-efficacy in digital competencies. Self-efficacy in digital competencies, in turn, was negatively associated with the experience of technostress creators. These findings provide evidence for implementing not only emotion regulation-based but also digital self-efficacy-based interventions to mitigate teachers' technostress.

Keywords Technostress, Cognitive emotion regulation, Self-efficacy, Digital proficiency, Secondary education

The pervasiveness of Information and Communication Technologies (ICTs) is an ongoing and ever-expanding phenomenon. The COVID-19 pandemic further accelerated this trend, leading to a sharp and widespread increase in remote work and the adoption of diverse ICT tools[1]. In particular, the digitalization process has been accelerated and enhanced in educational institutions to strengthen educational quality, resulting in the widespread implementation of distance learning and technology-based approaches. However, this intense reliance on technology requires teachers to manage multiple ICT tools simultaneously to meet educational objectives while continuously upgrading or developing skills and competencies to keep up with ever-evolving demands[2]. Moreover, the ubiquitous nature of ICTs has made teachers constantly connected and thus reachable beyond working hours.

Nonetheless, the challenge of integrating ICTs into teachers' practices and communication has consistently proven to be a complex matter, shaped by a wide array of interrelated and diverse influencing factors[3,4]. These elements can serve either as enablers that promote the use of technology or as obstacles that hinder its implementation in educational settings. They are generally classified into internal or individual factors and external or contextual factors[5]. This constant need to adapt to ICT demands and the lack of integration among many factors can increase teachers' stress levels in using ICTs. So, stress is a process shaped by individual experience and perception, and when it is directly or indirectly induced by ICT use, it is called *technostress*[6,7].

In the present study, we investigated the negative experience associated with technostress among secondary-school teachers. Namely, we examined the role of teachers' emotion regulation strategies and self-efficacy in

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digital competencies in shaping such experience, providing knowledge for potential interventions aimed at reducing technostress in educational settings.

Literature review and hypotheses development

Technostress among teachers

Technostress, defined by Brod[8] as the "inability to adapt or cope with new computer technologies in a healthy manner" (p.8), represents a significant downside of the technological permeation in modern society, impairing individuals' ability to cope with the constant emergence of new technologies[8,9]. Several results indicate that technology-based stressors can induce physiological stress responses[10,11]. Generally, while acute responses to mild stressors can be adaptive, prolonged exposure to stress may negatively impact individual well-being[12]. In this vein, technostress creators can significantly harm chronically exposed people. Indeed, it has been shown that technostress leads to a wide range of psychological (e.g., burnout, role conflict) and behavioral (e.g., technology use patterns, productivity, performance) consequences in both organizational and private contexts (for a meta-analysis, see [13]).

Technostress in the work context has attracted wide attention in recent years, alongside other technology-related conditions such as *technophobia* (the fear of ICT use and worries concerning its societal effects) and *technoaddiction* (the compulsive use of technological devices like computers and smartphones[14,15]). However, unlike these behavioral disorders, technostress is commonly experienced by teachers in different domains. Techno-overload (the tendency of technology to push individuals to work more and faster than their capacity allows), techno-invasion (the constant connectivity and availability imposed by ICTs), and techno-complexity (the difficulty in mastering complex technologies, leading to feelings of inadequacy despite efforts to learn ICT use) are among the leading causes of technostress. Following Tarafdar et al.[9], together with techno-uncertainty, which concerns the continuous changes and upgrades required by current ICTs, and techno-insecurity, regarding feelings of being replaced by technologies or others having better digital competencies, they represent the five technostress creators. Technological systems and conditions having these characteristics can become technostress creators when perceived as threatening by ICT users[16]. The extent to which users report experiencing technostress in these areas is commonly used as an indicator of its psychological impact.

The experience of technostress creators is widely spread among teachers and has been highlighted by recent studies indicating that teachers perceiving high technostress reported lower job satisfaction and organizational commitment, as well as increased workload and emotional exhaustion[17–20]. Given their adverse influence on teachers' well-being and education quality, technostress creators must be investigated to understand the antecedents, i.e., the factors affecting or predicting the technostress experience, and to help identify protective and risk factors, paving the way for targeted interventions aimed at supporting teachers. While this work's focus is on the negative side of technostress, it is worth noting that beneficial effects have also been observed (e.g.,[21,22]) and conceptualized within the holistic technostress model[23]. The observation of techno-eustress, which has also been studied among teachers[24,25], strengthens the idea that the psychological experience of technostress creators is largely shaped by the person–environment relationship.

Research on technostress has widely adopted the transactional theory of stress[26,27]. Following this line, in their model of technostress, Ragu-Nathan et al.[26] described technostress creators as those events and conditions related to technologies that generate stress in ICT users. In their model, the experience of technostress creators influences job satisfaction as a primary outcome variable, which has organizational commitment and continuance commitment as subsequent organizational outcomes. This relationship is moderated by technostress inhibitors, which are contextual factors attenuating the negative impact of technostress creators. Finally, the authors noted that individual differences in terms of age, gender, education, and ICT confidence affect users' beliefs and reactions towards technologies[26].

According to the resources-experiences-demands (RED) model[28], work-related stress arises from the joint effect of job demands and the availability of job and personal resources to cope with these demands. In this regard, studies have shown that emotional overload (a job demand) and lack of mental competencies (a personal resource) are associated with technostrain feelings[28], while digital skills, confidence, and self-efficacy negatively influence technostress[14,26]. Therefore, the increasing demands for skills and knowledge for ICT use, the continuous changes in learning and teaching processes and practices, and consequently the time and effort necessary to adapt and learn how to use ICTs cause technostress in teachers, particularly when they lack appropriate coping strategies and digital proficiency. While the relationship between digital proficiency and self-efficacy and technostress has been widely studied, the exploration of the role of emotion regulation mechanisms and their interaction with digital proficiency in shaping technostress among teachers is scattered to date. Unraveling the individual factors associated with the experience of technostress creators among teachers would be crucial to aid schools in promoting interventions to improve teachers' beliefs and reactions toward the adoption of ICTs.

Emotion regulation and technostress

According to the transactional theory of stress[29], stress arises from an imbalance between environmental demands and an individual's ability to cope with them. Two key mediators act on this interaction: cognitive appraisals and coping[29]. Cognitive appraisals refer to how an individual evaluates a stressor (i.e., whether it is perceived as a threat, challenge, or harm/loss) and its relevance—namely, primary appraisals—as well as the available coping resources to deal with it—i.e., secondary appraisals. Primary and secondary appraisals interact in shaping an individual's emotional experience. Coping refers to reactive cognitive and behavioral responses individuals use to manage or tolerate stressors[29,30]. Behavioral coping strategies have been shown to play a role in the experience of technostress. Pirkkalainen et al.[27] showed that both reactive and proactive coping strategies can help mitigate the negative effects of technostress on productivity. Instead, Hauk et al.[31] found that older individuals experience lower levels of technology-related strain, partly due to their reduced reliance on behavioral disengagement coping strategies.

Extensive evidence shows that different strategies for managing stress have varying effects on individual health[30]. For instance, one well-established distinction is between problem-focused and emotion-focused strategies[29]. The former involves efforts to improve the person-environment fit, while the latter consists of cognitive and behavioral strategies aimed at mitigating the emotional impact of a stressor. It has been reported that problem-focused coping has been more extensively studied than emotion-focused coping as an intervention to counteract technostress[32]. While problem-focused coping is generally thought to be more effective than emotion-focused coping in reducing negative emotions, authors have suggested this is not the case when individuals have limited control over stressful situations[33]. Indeed, emotion-focused coping strategies become more prominent in such cases[34]. In the ICT field, emotion-based coping strategies may also modulate the subsequent use of problem-based strategies[35], while positive emotions have been found to enhance task performance under technostress conditions[32].

Beyond the distinction between problem-focused and emotion-focused coping, some authors have proposed differentiating between the cognitive and behavioral dimensions of emotion regulation[36]. Emotion regulation generally encompasses the conscious and unconscious processes that monitor and modify the intensity and nature of emotional experiences in response to specific events[37]. The cognitive component of emotion regulation subtends the cognitive management of emotions, reflecting on a stressful situation. Thus, it plays a crucial role when overt behavioral responses are limited, insufficient, or constrained by external demands, as is often the case with ICT-related stressors characterized by overload, invasion, or possibly low digital competencies. In these contexts, enhancing the use of cognitive emotion regulation would be fruitful since these appraisal processes occur before actions are taken, gaining consciousness about one's emotional reactions[36]. Theoretically speaking, cognitive emotion regulation strategies (CERs) can be distinguished into adaptive and maladaptive strategies based on their association with mental health outcomes and coping[36]. Among the studied CERs, adaptive strategies involve positive refocusing, positive reappraisal, putting into perspective, refocus on planning, and acceptance. For instance, positive reappraisal strategies involve reinterpreting a stressful person-environment interaction in terms of personal growth, while refocus on planning reflects thinking about the concrete steps to take in order to deal with the stressor. In terms of ICTs, the experience of failures or difficulties in the use of technologies can be reappraised positively by focusing on ICT learning or by directing attention to the single necessary steps to take to avoid overload. Instead, maladaptive strategies include rumination, self- and other-blame, and catastrophizing. For example, through rumination, the individual strongly focuses on thoughts and feelings associated with the negative, stressful situation[36]. In the context of technology use, these thoughts may focus on one's skills in using ICTs.

Adaptive CERs, such as reappraisal, are associated with better affective, social, and health outcomes than maladaptive strategies[38]. The habitual use of adaptive strategies was linked with higher subjective well-being, while maladaptive strategies were associated with poorer well-being[39]. Their use is linked to affective disturbances: higher engagement in maladaptive strategies and lower use of adaptive ones are associated with depression and anxiety[40–42]. On the physiological level, both types of strategies were found to increase cortisol reactivity to an experimentally induced acute psychosocial stressor[43]. Adaptive and maladaptive emotion regulation strategies were also found to be differently associated with health outcomes, like inflammation[44]. However, a meta-analysis has shown that the reliance on maladaptive strategies is more strongly associated with psychopathological outcomes than the lack of adaptive strategies[40]. Relatedly, research by Gaudioso et al.[45] has investigated how different coping strategies directed at technology-related stressors among employees act as mediators between technostress (techno-overload and techno-invasion) and work exhaustion. They found that maladaptive, more than adaptive, coping strategies are used by employees to manage work-family conflicts and distress generated by technology. However, while these coping strategies are reactive to specific kinds of technostress, it is currently unclear whether the habitual use of CERs can also influence technostress creators. Since CERs can be trained regardless of the experience of technostress, their use by teachers can be generalized, potentially affecting general well-being. In the present work, we hypothesize that CERs are associated with technostress creators among teachers according to their adaptiveness.

H1a Maladaptive cognitive emotion regulation strategies have a direct positive influence on technostress creators.

H1b Adaptive cognitive emotion regulation strategies have a direct negative influence on technostress creators.

Self-efficacy in digital competencies

Self-efficacy refers to individuals' judgments of their capabilities in executing actions to achieve specific performance goals and confidence in controlling the determinants of these behaviors[46]. Self-efficacy shapes what individuals believe they can accomplish regarding a particular task and determines their persistence and resilience in facing difficulties[47]. At school, teachers' self-efficacy is crucial to education quality. Indeed, research has shown that teacher self-efficacy is positively associated with teachers' and students' motivation and attitudes[48], influencing job-related satisfaction[49]. The widespread increase in the adoption of new technologies, such as generative artificial intelligence, in learning environments, makes the study of literacy and self-efficacy on the one hand and emotions on the other hand of primary importance for understanding differences in students' learning outcomes and technology acceptance, for instance in foreign language learning[50–52]. Students' self-efficacy for foreign language receptive skills, in this regard, has been shown to mediate acceptance of new technologies, such as generative artificial intelligence, in language learning and teachers' perceived enthusiasm and individual well-being[52]. In the present study, we focus on self-efficacy in digital competencies[47] as a critical factor influencing technostress among secondary-school teachers. Teachers' beliefs about their ability to effectively use digital tools significantly influence their adoption and continued usage of technology. Indeed, literature has shown that teachers' digital self-efficacy is positively linked with digital competencies[53] and the intention to use digital tools for educational purposes[54]. Among teachers, digital information literacy has been found to significantly mediate the association between the psychological adaptability of teachers and work engagement[55]: higher adaptability increases self-efficacy, which in turn positively relates to work engagement. Also, Mannila et al.[47] reported that self-confidence in teachers' digital competencies was associated with work adaptability in using new digital tools. Studies investigating self-efficacy in computer use have found that individuals with high self-efficacy tend to use the computer more, are less resistant to technological changes, and are less anxious about the use of computers than individuals with low self-efficacy[56–58]. Research has shown that low digital self-efficacy is significantly associated with high levels of technostress and reduced ICT adoption[59], also among teachers[60,61].

The mediating role of self-efficacy in digital competencies

Personal resources to cope with stress are crucial in the appraisal process[29]. As an important aspect of behavioral regulation mechanisms, general self-efficacy has been included by several authors within the variables involved in cognitive appraisal and coping processes under stress[62]. Low self-efficacy in digital competencies may thus increase the likelihood of experiencing ICT demands as taxing the person-environment relationship, thus increasing perceived technostress and reducing the capabilities of individuals to master the situation and cope with it[59]. Therefore, digital self-efficacy may represent a key factor influencing secondary appraisal processes related to technostress.

We considered self-efficacy in digital competencies as a critical mediator between the use of adaptive and maladaptive cognitive emotion regulation strategies and perceived technostress creators. Theoretical models have described emotion regulation as a process, emphasizing the use of specific strategies, and as an ability, focusing on the habitual way of responding to emotional experience, suggesting a bidirectional influence between them[63,64]. Relatedly, authors have proposed that the use of emotion regulation strategies can result in changes in goal-directed behavior[65].

Emotional states and arousal are among the major sources of information for self-efficacy, according to the self-efficacy theory[46]. The habitual way of managing one's own emotional activations may thus aid individuals in facing taxing tasks, like those relying upon the extensive use of technologies. For example, individuals who are more likely to use adaptive strategies such as reappraisal may frame novel ICTs as a challenge and thus increase their self-efficacy in learning and using technologies. In contrast, those who use maladaptive strategies such as rumination may be more likely to incorporate negative feelings into their own belief about self-efficacy in digital skills. In support of this directional hypothesis, prior evidence has established the mediating role of self-efficacy in academic performance (e.g.,[66]). Similarly, Freire and colleagues found that students who reported greater flexibility in coping strategies also scored higher on general self-efficacy, and discussed the mediating role of self-efficacy in the relationship between coping strategies and stress[67]. This proposed mediation finds further empirical support from previous research highlighting clear links between personality and perceived stress[68], emotional intelligence traits and stress-related performance[69], and between technostress and negative outcomes (i.e., resistance to innovation[70]), through the mediation of self-efficacy. Crucially, Levante et al.[19] recently demonstrated a related sequential mediation in teachers during the COVID-19 pandemic, where coping strategies reduced emotional exhaustion indirectly via increased online teaching self-efficacy, which in turn decreased emotional exhaustion. Although not identical, these findings strongly support the theoretical plausibility of our hypothesized mediation pathway.

This mediating role of digital self-efficacy is theoretically grounded in both Lazarus and Folkman's transactional stress theory and Bandura's self-efficacy theory. According to Lazarus and Folkman[29], individuals' experiences of stress depend significantly on their secondary appraisal process, in which they evaluate personal resources and coping abilities. Self-efficacy beliefs, as outlined by Bandura[46], are particularly sensitive to emotional states, which are influenced directly by the habitual use of CERs. Teachers who regularly employ adaptive strategies (e.g., positive reappraisal, planning) could be more likely to experience positive emotions, enhancing their self-efficacy in digital competencies. Conversely, teachers who frequently adopt maladaptive strategies (e.g., rumination, catastrophizing) could experience negative emotional states, thereby diminishing their self-efficacy. Consequently, higher self-efficacy in digital competencies might enable teachers to appraise technological demands as manageable rather than overwhelming, reducing technostress perceptions. This interpretation is also consistent with the RED Model[28], which emphasizes self-efficacy as a crucial personal resource in managing work-related stress.

For the purposes of the present work, self-efficacy may increase or decrease according to the predominant use of adaptive and maladaptive strategies, respectively, further lowering or reinforcing the experience of technostress creators.

H2 Self-efficacy in digital competencies mediates the effect of adaptive and maladaptive coping strategies on technostress creators.

Furthermore, among the antecedents of technostress, age, gender, and education have been found to play significant roles, as also included in the transactional model of technostress[26]. Research suggests that technostress is more likely to be experienced by older than younger individuals, by males more than females, and by those with lower education levels more than those with higher levels of education[14,26]. In addition, older teachers reported higher levels of technostress than younger ones[19]. Therefore, we used these variables as covariates to control the effects of cognitive emotion regulation strategies and digital self-efficacy on the experience of technostress creators.

Methods

Participants and procedure

A cross-sectional online investigation on technostress among secondary school teachers was conducted. Respondents were recruited through voluntary participation, facilitated by a project sponsorship campaign, adopting a non-probabilistic snowball sampling approach. A link to the Qualtrics survey platform for participation was disseminated among teachers through various channels (e.g., internal school communications, training activities, social media, and e-mail). The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and complied with the Ethical Code of the Italian Association of Psychology (AIP). Ethical approval was granted by the Institutional Review Board of Psychology (IRBP) of the Department of Psychology at the University "G. d'Annunzio" of Chieti-Pescara (protocol number: 24026, approved on November 22, 2024). Informed consent was obtained from all participants prior to their participation in the study. The data presented in this study constitute part of a broader research project investigating technostress among secondary school teachers, and further data for different purposes will be presented elsewhere.

An a priori power analysis estimated that 138 participants were sufficient to detect an effect size $f^2 = 0.15$, with a significance level of $\alpha = 0.05$ and a power of 95% in a regression model with five predictors. Participants who reported being elementary school teachers, trainees, or other professionals were not included. Three hundred forty-eight complete responses were included (*M* age = 44.6 years, *SD* = 10, range 24–68). Of the 348 participants, 286 identified as females, 58 as males, 1 as non-binary, and 3 did not disclose their gender. Regarding teaching experience, 36% had less than five years of experience, 33% between five and ten years, and 31% ten years or more (*M* = 9.7 years; range 0–41). A university degree was held by 89.1%, while the remaining had a high school diploma.

Measures

Technostress Creators Scale (TCS). The TCS[9] consists of thirty-six items. Of these, 23 correspond to the five technostress creators' subscales, each describing specific situations in which ICTs create stress (techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty). The three additional scales from Tarafdar et al.[9], measuring role overload, role conflict, and productivity, were also administered. However, these were not included in the analysis as they are not directly inherent to technostress.

The questionnaire was translated into Italian using a back-translation method. Participants answered using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The average score for each of the five technostress creators was computed. Cronbach's alpha for the subscales ranged from 0.762 to 0.880, which are commonly considered as indicating good to high internal consistency[71] in this sample. Using confirmatory factor analysis (CFA), the fit of the 5-factor structure described in Tarafdar et al.[9] was evaluated, by means of the RMSEA (Root Mean Square Error of Approximation; values ≤ 0.05 suggest close or good fit, values ≤ 0.08 suggest reasonable or acceptable fit, and values ≥ 0.10 suggest poor fit) and SRMR (Standardized Root Mean Square Residual; values ≤ 0.05 suggest good fit, values ≤ 0.10 suggest acceptable fit)[72–75]. In addition, the GFI (Goodness of Fit Index; values ≥ 0.95 for good and ≥ 0.90 for acceptable fit[73]) and χ^2/df (values ≤ 2 for good and ≤ 3 for acceptable fit[73]) are reported. The obtained values were: $RMSEA = 0.073$, $SRMR = 0.060$, $GFI = 0.946$, $\chi^2\ (220) = 631.887$, $p < 0.001$, $\chi^2/df = 2.872$, suggesting acceptable fit. The five scores were averaged together to obtain a global index of technostress: the higher the score, the higher the overall perception of technostress. The sample's scores followed an approximately normal distribution, as indicated by skewness (0.213) and excess kurtosis (− 0.064), both well within acceptable limits (absolute values of skewness > 2 or proper kurtosis > 7 may suggest substantial departure from normality[76]).

Self-Efficacy Digital Competencies (SDC). We administered a 27-item questionnaire[47,77] assessing self-efficacy in different areas of digital competence (information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving). The questionnaire was translated into Italian using a back-translation method. Participants rated their confidence on a 7-point Likert scale, ranging from 1 (very uncertain) to 7 (very confident). Based on the five competence areas described by Nordén et al.[77] and Mannila et al.[47], a 5-factor solution using CFA provided mixed fit, $RMSEA = 0.093$, $SRMR = 0.068$, $GFI = 0.924$, $\chi^2\ (314) = 1258.391$, $p < 0.001$, $\chi^2/df = 4.008$. Individual cumulative self-efficacy scores were computed as the sum of the scores on all the item responses (the higher the score, the higher the overall self-efficacy in digital competencies)[47]. Cronbach's alpha was 0.952, a value commonly considered as indicating excellent internal consistency in this sample. The skewness (− 0.094) and excess kurtosis (− 0.396) values indicate that the distribution of the scores follows an approximate normal distribution.

Cognitive Emotion Regulation Questionnaire-Short (CERQ). We used the Italian-validated version of the CERQ-S[78] to assess teachers' use of adaptive and maladaptive cognitive emotion regulation strategies. Participants indicated on a 5-point Likert scale, ranging from 1 (almost never) to 5 (almost always), how often they used the strategy depicted on each item. The nine strategies described in the questionnaire (two items each) were grouped into adaptive (CERQa: putting into perspective, positive refocusing, positive reappraisal, acceptance, and planning) and maladaptive (CERQm: self-blame, other-blame, rumination, and catastrophizing) categories. Although we used the already validated Italian version[78], a CFA on the 9-factor solution was conducted, suggesting good fit, $RMSEA = 0.044$, $SRMR = 0.036$, $GFI = 0.993$, $\chi^2\ (99) = 167.192$, $p < 0.001$, $\chi^2/df = 1.689$. The two scores (CERQa and CERQm) were computed as the sum of the scores on the associated items. The higher the score, the greater the use of that cognitive emotion regulation strategy. Cronbach's alpha was 0.796 for the CERQa and 0.774 for the CERQm, commonly suggested as indicating good and reasonable internal consistency in this sample. Skewness values are acceptable for both scores (− 0.805 and − 0.079 for CERQa and CERQm, respectively). The distribution tended to be leptokurtic for the CERQa, but within acceptable limits (excess kurtosis: 2.639 and 0.260 for CERQa and CERQm, respectively).

Data analysis

Pearson's correlations were computed to examine the relationships between variables. To examine the predictive role of emotion regulation on technostress, mediation analyses were run using the PROCESS macro (Model 4) for SPSS with 5000 bootstrap samples. Separate models were run for CERQa and CERQm as predictors. In both models, the cumulative SDC score was included as the mediator, and the overall TCS score was included as the outcome variable. Teachers' age, gender, and education level were included as covariates. Given the small number of non-binary (N = 1) participants and participants who did not disclose their gender (N = 3), we included only females and males in the mediation analyses (0 = female, 1 = male). Education level was treated as a dichotomous variable, with university degrees coded as 0 and a high school diploma coded as 1. The alpha level was set at 0.05.

Results

Common method bias

As a preliminary analysis, we conducted Harman's single-factor test[79] on all the item scores from the TCS, SDC, and CERQ questionnaires to test for the presence of Common Method Bias. The variance explained by a single-factor model using exploratory factor analysis was 18.16%, below the commonly recommended threshold of 50%[80]. In addition to the fact that respondents were explicitly told that there were no right or wrong answers and that their answers would remain anonymous and confidential, this suggests no concerns regarding shared measurement methods.

Correlation analyses

Descriptive statistics and Pearson's correlations among the variables are reported in Table 1. Adaptive cognitive emotion regulation strategies (CERQa) showed a weak but statistically significant positive correlation with the techno-uncertainty subscale of the TCS. In contrast, maladaptive cognitive emotion regulation strategies (CERQm) showed significant but weak positive correlations with all Technostress Creators subscales. SDC showed weak negative correlations with techno-overload and techno-insecurity and a moderate negative correlation with techno-complexity. SDC showed weak positive correlations with CERQa. Weak to moderate statistically significant correlation coefficients were observed between all the Technostress Creators subscales.

Mediation analyses

Two separate mediation analyses (N = 344) were conducted to examine the relationship between maladaptive and adaptive CERs and overall experience of technostress creators (TCS), and the mediating role of SDC.

The total effect of CERQm on technostress creators was significant, $b = 0.054$, $SE = 0.007$, $t = 7.680$, $p < 0.001$, $\beta = 0.389$, as was the direct effect, $b = 0.055$, $SE = 0.007$, $t = 8.099$, $p < 0.001$, $\beta = 0.395$. CERQm was not significantly associated with SDC, $b = 0.152$, $SE = 0.336$, $t = 0.453$, $p = 0.651$, $\beta = 0.024$. SDC was negatively associated with technostress creators, $b = -0.006$, $SE = 0.001$, $t = -5.228$, $p < 0.001$, $\beta = -0.262$ (Fig. 1). The indirect effect (maladaptive CER → SDC → technostress creators) was not statistically significant, $\beta = -0.006$, *95% BootCI* = [− 0.038, 0.027]. The model was significant $F_{5,338} = 18.99$, $p < 0.001$, $R^2 = 0.219$.

The total effect of CERQa on technostress creators was not significant, $b = -0.002$, $SE = 0.006$, $t = -0.268$, $p = 0.789$, $\beta = -0.015$. The direct effect of CERQa on technostress was also not significant, $b = 0.005$, $SE = 0.006$, $t = 0.713$, $p = 0.476$, $\beta = 0.038$. CERQa was positively associated with SDC, $b = 1.099$, $SE = 0.276$, $t = 3.98$, $p < 0.001$, $\beta = 0.204$, which was also negatively associated with technostress creators, $b = -0.006$, $SE = 0.001$, $t = -4.65$, $p < 0.001$, $\beta = -0.260$ (Fig. 2). The indirect effect (adaptive CER → SDC → technostress creators) was statistically significant, $\beta = -0.053$, *95% BootCI* = [− 0.088, − 0.021]. The model was significant $F_{5,338} = 5.03$, $p < 0.001$, $R^2 = 0.069$.

In both models, none of the three covariates (i.e., gender, age, and education level) were significantly associated with the experience of technostress creators.

For informative purposes, to verify the relationship observed in the mediation models, two separate stepwise regression analyses (entry probability $F \leq 0.05$, removal probability $F \geq 0.10$) were conducted on the same sample, entering the variables included in the two models as predictors and the level of experienced technostress creators as the dependent variable. Continuous variables were transformed into z-scores. The CERQm regression model included only CERQm, $\beta = 0.381$, $t = 7.626$, $p < 0.001$, at a first step, $F_{1,342} = 58.16$, $p < 0.001$, explaining 14.5%

	M (SD)	TCS Overload	TCS Invasion	TCS Complexity	TCS Insecurity	TCS Uncertainty	SDC	CERQa	CERQm
TCS Overload	2.66 (0.97)	–							
TCS Invasion	2.68 (1.05)	.55***	–						
TCS Complexity	2.62 (0.97)	.44***	.33***	–					
TCS Insecurity	1.91 (0.73)	.40***	.45***	.52***	–				
TCS Uncertainty	2.83 (0.91)	.26***	.33***	.38***	.38***	–			
SDC	114.03 (30.75)	− .11*	− .04	− .52***	− .23***	− .07	–		
CERQa	34.57 (5.68)	− -.05	− .00	− .08	− .05	.15**	.18***	–	
CERQm	22.83 (4.82)	.21***	.30***	.28***	.27***	.31***	.02	.09	–

Table 1. Descriptive statistics and Pearson's correlations among the variables. TCS = Technostress Creators Scale; SDC = Self-efficacy in Digital Competencies; CERQa = Cognitive Emotion Regulation Questionnaire—adaptive; CERQm = Cognitive Emotion Regulation Questionnaire—maladaptive. *$p < .05$, **$p < .01$, ***$p < .001$.

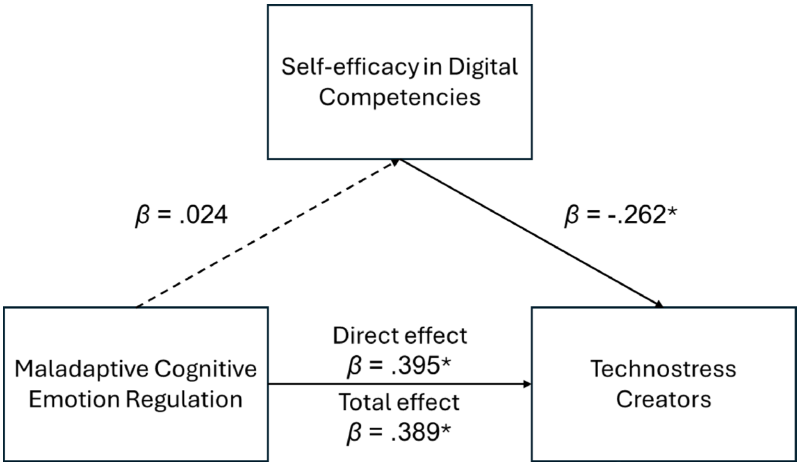

Fig. 1. Results of the mediation model with CERQm as a predictor. The reported values are standardized coefficients. *$p < .001$.

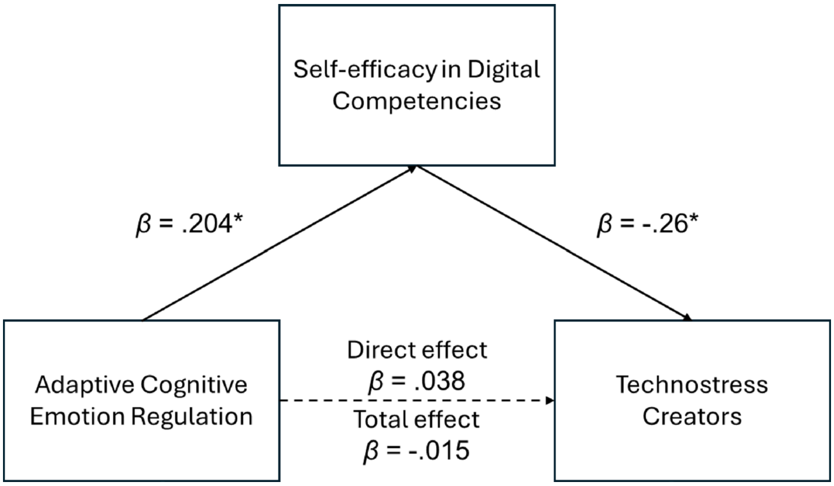

Fig. 2. Results of the mediation model with CERQa as a predictor. The reported values are standardized coefficients. *$p < .001$.

of variance. In a second step, together with CERQm, $\beta = 0.386$, $t = 8.058$, $p < 0.001$, also SDC was included, $\beta = -0.265$, $t = -5.535$, $p < 0.001$, explaining together 21.6% of variance. The model was statistically significant, $F_{2,341} = 46.916$, $p < 0.001$, $R^2_{change} = 0.07$, $F_{change\ 1,341} = 30.633$, $p < 0.001$. Instead, the resulting CERQa regression model included only SDC, $\beta = -0.258$, $t = -4.935$, $p < 0.001$. The model was statistically significant, $F_{1,342} = 24.357$, $p < 0.001$, $R^2 = 0.066$. The results confirm the primary roles of maladaptive CERs and SDC on the experience of technostress creators as reflected in the mediation analyses.

Discussion

In the present work, we focused on the roles of cognitive emotion regulation and self-efficacy in digital competencies as individual antecedents of technostress among secondary-school teachers. While confirming the crucial role of self-efficacy in digital competencies in the experience of technostress creators, we found that cognitive emotion regulation strategies seem to have more complex effects depending on their adaptiveness.

Cognitive emotion regulation strategies and technostress

We found that using maladaptive cognitive emotion regulation strategies (self- and other-blame, rumination, and catastrophizing) was directly and positively associated with teachers' experience of technostress creators, thus supporting H1a. This result extends findings from studies showing that maladaptive cognitive emotion regulation strategies can heighten affective disturbances[36,40]. In addition, several studies have found that maladaptive CERs positively predict problematic smartphone and social network use among the population. For instance, Elhai et al. found that the use of expressive suppression of negative emotions significantly predicted objective smartphone use[81] and also mediated the association between self-reported problematic use of smartphones and anxiety[82]. Further, maladaptive CERs were found to mediate the effect of social anxiety on problematic media and smartphone use[83]. In the context of technostress, our results partially parallel research on technostress-related coping, which indicates that maladaptive coping mediates the link between technostress creators (overload and invasion) and work exhaustion[45]. However, CERs are broader in scope and can be practiced independently of specific stress experiences, enhancing their generalizability to many technostress situations. Notwithstanding, correlation analyses in the present studies have further confirmed that maladaptive CERs are significantly associated with all the considered technostress creators. Although they are useful to "escape" from stressful situations and relieve the adverse effects of these creators in the short term, maladaptive CERs may be highly disadvantageous in the long run and further increase the perception of technostress creators.

Conversely, we found that adaptive CERs (putting into perspective, positive refocusing, positive reappraisal, acceptance, and planning) were not directly associated with the experience of technostress creators, thus not supporting H1b. It is important to consider that various contextual factors can influence the efficacy of CERs that are typically considered adaptive, like positive reappraisal. Indeed, these strategies may be less effective in alleviating negative emotions when the stressor is particularly intense and when individuals face time constraints[84]. Teachers must often accomplish technology-based tasks under time pressure and fatigue. Thus, in these conditions, using certain strategies like reappraisal alone may not be successful and may not directly turn into a significant reduction in overall experienced technostress. For instance, we found that adaptive CERs correlated weakly but positively with techno-uncertainty, highlighting the multifaceted complexity of the relationship between emotion regulation and technostress creators.

Taken together, these results confirm and extend the evidence highlighting that maladaptive emotion regulation strategies are more strongly associated with negative affective outcomes than adaptive ones[40,45].

The mediating role of self-efficacy in digital competencies

We found that teachers' self-efficacy in digital competencies was significantly and negatively associated with technostress creators. This finding aligns with previous works[19,26] and supports the view that confidence in digital skills plays a protective role in the experience of technostress. The relationship between self-efficacy in digital competencies and technostress can be better understood through the RED model[28] and the transactional stress theory[26,29]. Digital skills, as personal resources, shape how individuals perceive and respond to work demands. When such resources are believed insufficient to deal with ICT-related demands, the chances for those demands to be perceived as stressful and overwhelming increase. Thus, the imbalance between the external demands and the resources to cope with those demands generates stress. Again, teachers lacking digital self-efficacy and proficiency may experience greater imbalance than skilled and confident teachers, thus triggering technostress experience. This result confirms the role of ICT confidence as a crucial individual factor influencing technostress creators, as described in the technostress model by Ragu-Nathan and colleagues[26]. Mannila et al.[47] showed that only 26% of teachers reported strong digital self-efficacy scores, while 18% reported low scores. They also reported that teachers are highly variable in their confidence across different areas of digital competencies. These data underscore the importance of improving teachers' digital self-efficacy in consideration of its role in modulating the negative sides of technology use.

Notably, the indirect effect of CERs on technostress creators was significant only for the model with adaptive strategies as focal predictors, thus partially confirming H2. Namely, adaptive CERs positively influence self-efficacy in digital competencies, ultimately lowering technostress creators. Psychological and neuroscientific research has widely recognized the impact of adaptive CERs, such as reappraisals, on affective states through supporting flexible contextualization in pursuing goal-directed behavior[85,86]. By considering self-efficacy as a belief about one's ability to direct resources to exercise control over events, general self-efficacy in students was found to be positively associated with adaptive strategies such as reappraisal and planning strategies[67] but not with maladaptive strategies such as suppression[86]. Similarly, recent evidence showed that self-efficacy mediated the relationship between emotional intelligence traits and performance under stress[69]. In particular, a recent study has shown that adaptive coping influences emotional exhaustion through teaching self-efficacy and technostress[19].

Our study extended the self-efficacy construct to a broader set of digital competencies[47] and reports evidence for its mediating role in the effect of adaptive cognitive emotion regulation strategies on technostress creators. The habitual use of strategies like reappraisal may drive teachers to see ICTs as a resource, boosting their perception of being effective in the use of technologies and having the capacity to master the ICT challenges[19]. On the other hand, the use of maladaptive strategies such as rumination or catastrophizing may directly strengthen the stressful experience. Thus, we highlighted how different internal cognitive dimensions may interact in the experience of technostress creators among teachers, providing useful knowledge to expand and contextualize theoretical models of technostress[26].

Therefore, the present results indicate that interventions based not only on emotion regulation but also aimed at increasing digital self-efficacy may effectively aid teachers in mitigating the experience of technostress creators and facing the long-term challenges that an ever-increasing adoption of ICTs would present. These interventions should focus on training teachers to reduce the use of maladaptive CERs (e.g., self-blame, other-blame, rumination, and catastrophizing) while promoting adaptive ones (e.g., positive refocusing, reappraisal, putting into perspective, acceptance, and planning), on the one hand, and increase self-efficacy in digital competencies on the other hand. In particular, literature has shown that even brief training interventions based on CERs may improve affective outcomes. For instance, two weeks of training on positive reappraisal have been shown to reduce perceived stress and negative affectivity after 4 weeks[87]. Similar programs can be adapted for the educational setting and included as part of teachers' training activities, together with those aimed at promoting proficiency and confidence in digital skills[47]. These interventions may enhance teachers' adaptability in facing ongoing technological innovations at school, resulting in improved well-being and educational outputs.

Limitations

The study presents several limitations that future research might overcome. The first limitation of the study lies in its cross-sectional design, which prevents drawing causal inferences from the results, unlike a longitudinal approach. Consequently, the observed mediation effects should be interpreted as associative rather than causal. Future longitudinal studies could address this limitation and better explore the dynamic interaction of technostress and emotion regulation strategies as teachers gain experience or develop digital skills. Relatedly, while we focused on a habitual, nonspecific measure of cognitive emotion regulation strategies, those involving ICTs need to be considered to draw parallels between them. In addition, the results of the present study should be generalized with caution. Considering the role of job-related variables, such as contract status or the number of students, and the impact of demographic and cultural variables, larger samples would provide important insights into the organizational and individual antecedents of technostress that may interact with individual emotion-based dimensions. Moreover, a larger sample size with a more balanced distribution of demographic variables would have revealed differences in technostress levels, as reported elsewhere (e.g.,[14,19,26]). Future studies might also include investigations of specific technostress creators to increase the understanding of which aspect is more influenced by cognitive emotion regulation and individual variables considered. Aggregating the five TCS dimensions into a single composite score may obscure specific effects associated with each creator. This, in turn, could limit the development of targeted interventions. Finally, one of the limitations of this study is the use of self-report measures. Thus, where feasible, integrating psychophysiological stress measures (e.g., cortisol, heart rate) would complement subjective reports and enhance our understanding of technostress antecedents.

Conclusions

The negative psychological experience associated with technostress among teachers is known to undermine the healthy adoption of ICTs and affect educational outputs, further influencing their well-being. Psychological science may offer substantial knowledge that can be used to mitigate the adverse effects of technologies in educational settings and further generalized to other settings. Our findings highlight the relevance of integrating psychological and technological approaches to address technostress, suggesting that fostering teachers' emotional regulation and digital self-efficacy could serve as key protective factors. The objective is to develop tools acting as effective countermeasures to the potential adverse effects of ICT use. These results align with and extend previous research (e.g.,[19,45]), pointing to the idea that potential interventions focused on emotional regulation combined with digital competence can significantly reduce the psychological burden associated with ICT use in professional settings. Cognitive emotion regulation strategies, both directly and indirectly through self-efficacy in digital competencies, play a key role in shaping the experience of technostress creators. While technological advancements require teachers to update their digital skills continuously, exposing them to ever-new challenges, the ability to regulate emotions cognitively can overlay specific ICT competencies and support well-being and educational outputs. Future studies could further explore how changes in digital self-efficacy and emotion regulation strategies influence the long-term impact of technostress in educational environments.

Data availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions

P.Z. analysed data and wrote the manuscript; G.M., M.L.M., and M.G.D. acquired data and reviewed the manuscript; A.D.D. and M.P.P. conceived and supervised the work, and reviewed the manuscript; M.P., conceived and supervised the work, administered the project, acquired data, and reviewed the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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