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Digital Competence as a Psychosocial Resource: A Structural Model of Technofatigue in Primary Education

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Abstract

The integration of Information and Communication Technologies (ICT) has generated new psychosocial challenges in the field of education, with techno-fatigue standing out as a barrier to teacher well-being. The aim of this study was to analyse the influence of Digital Teaching Competence (DTC) on cognitive fatigue, evaluating the role of sociodemographic variables using a structural equation model (SEM). A total of 1,400 teachers (n=1,400) from early childhood and primary education in Andalusia (Spain) participated. The results revealed that DTC acts as a significant protective factor against fatigue. Likewise, gender and age were found to be positive predictors of levels of technological exhaustion. It is concluded that strengthening digital competence, especially in the areas of professional commitment and empowerment, is essential to mitigate the psychosocial risks associated with the use of technology in the classroom.

Keywords: Digital competence, Techno-fatigue, Occupational health, Primary education, Structural equation modelling, DigCompEdu

Introduction

In today's knowledge society, the integration of Information and Communication Technologies (ICT) has become a prerequisite for the development of education (Aguilar et al., 2022; Cabero et al., 2020). Digital Teaching Competence (DTC) is defined as a complex construct that encompasses the skills, attitudes, and knowledge necessary for teachers to facilitate their students' learning in the digital world (Olmo and Alba, 2023). Internationally, the development of DTC is based on established frameworks such as the European Framework for the Digital Competence of Educators (DigCompEdu) (Redecker, 2017).

Within this framework, DTC is defined not only as the ability to use tools, but also as the ability to orchestrate digital teaching strategies that promote the implementation of these devices in the classroom, as well as the ability to develop digital skills in students (Cid, Aznar, Gómez-García, & Maldonado, 2025). This framework comprises six dimensions:

- Professional commitment: use of digital tools for communication, professional collaboration

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and continuous teacher development.

- Digital resources: selection, creation and management of digital resources relevant to learning.
- Digital pedagogy: application of digital technologies to design, implement and evaluate innovative pedagogical strategies.
- Assessment and feedback: use of digital tools to assess, provide feedback and personalise learning.
- Student empowerment: promotion of autonomy, accessibility and inclusion through digital resources and strategies.
- Facilitation of students' digital competence: development of students' digital skills for creativity, problem solving and digital citizenship.

Despite the implementation of these regulatory frameworks, current research consistently reveals that the level of ICT proficiency among early childhood and primary school teachers is, for the most part, medium or intermediate (Aznar et al., 2025; Aiastui, Arruti, & Morillo, 2021). This gap between ideal and perceived competence suggests that instrumental mastery alone does not guarantee effective pedagogical integration (Olmo, & Alba, 2023). Furthermore, teachers tend to have a lower perception in critical areas such as digital security and ethics, highlighting the need for continuous and holistic training (Mañas, & González, 2023; Méndez et al., 2017). The lack of robust ICT not only limits methodological innovation, but also acts as a direct precursor to psychological distress in the face of technological pressure (Cabero et al., 2020; Trujillo et al., 2020). Similarly, not having the right infrastructure and enabling conditions to promote the integration of technological devices in the classroom is also identified as a key factor affecting teachers (Wang, Zhao, & Zeng, 2024).

On the other hand, the massive introduction of ICT, exacerbated by the COVID-19 health crisis and the transition to teleworking, has given rise to negative psychosocial phenomena encompassed under the concept of technostress (Estrada et al., 2021; Dogan, & Arslan, 2026; Golz et al., 2021 Domínguez et al., 2021). Technostress is conceptualised as a negative psychological state related to the use of technology, manifesting itself through dimensions such as anxiety about ICT, cognitive fatigue (technostress), scepticism and perceived ineffectiveness (Anis, 2024). Anxiety is defined as a state of agitation or fear derived from interaction with digital tools, while cognitive fatigue corresponds to mental exhaustion resulting from information overload and excessive energy expenditure involved in the continuous learning of new, unmastered tools (Niu et al., 2022; Sandín et al, 2020; Salanova et al, 2007). Similarly, within the framework of job demands and resources (JD-R), digital transformation can be understood as an intensification of job demands, while digital competence can function as a personal resource that buffers negative effects such as technological fatigue (Bakker et al., 2023; Bakker & de Vries, 2020).

The scientific literature indicates a significant correlation between low levels of DTC and the onset of technostress symptoms (Ávila-Sánchez et al., 2024; Chen, Wu, & Chuang, 2024). Teachers who perceive a lack of personal resources to meet technological demands experience higher levels of emotional exhaustion and a decrease in their well-being at work (Mesurado, & Laudadio, 2019). Anxiety and fatigue not only affect teachers' mental health, but also act as barriers to the implementation of active pedagogies, generating resistance to organisational change (Fuentes, López, & Pozo, 2019). Therefore, DTC acts as a protective factor or personal resource that can mitigate the deleterious effects of technological demands in the school environment (Ishan, Kamal, & Hussain, 2025; Bartra et al., 2024).tecnológicas en el entorno

escolar (Ishan, Kamal, & Hussain, 2025; Bartra et al., 2024).

Likewise, the onset of technostress is conditioned by various sociodemographic and professional variables that act as critical determinants. The most notable ones are listed below:

a) Age: this is one of the most influential factors, with previous research finding a positive correlation between advanced age and higher levels of anxiety, scepticism and technological inefficiency (Baiges, Lázaro, & García, 2024;). Older teachers often report lower perceived self-efficacy and greater fatigue in the face of the need to constantly update their skills (Cedeño, Mendoza, & García, 2022; Golz et al., 2021).

b) Gender: studies show complex results. While some indicate that men have a greater self-perception of competence in technical areas and problem solving, women tend to report higher levels of anxiety and fatigue, especially in contexts of telework overload (Sánchez-Prieto et al., 2020; González-Medina et al, 2024; Fernández, & Silva, 2022);

c) Teaching experience and training: there is an inverse relationship between specific ICT training and perceived stress (Kalasak, 2022; Centeno-Caamal, 2021). Training acts as a mediator of self-efficacy, reducing anxiety and allowing for a smoother transition towards the school's digital maturity. Interestingly, some studies suggest that novice teachers show better levels of DTC but may be vulnerable to burnout if they lack institutional support (Fernández Arias et al., 2024).

Although there are numerous studies that describe the relationship between digital competence in teaching as a possible mitigating factor for cognitive fatigue, the network of interactions between these variables justifies the need for complex explanatory models that allow us to identify not only the direct effects, but also the mediations between the constructs of digital competence in teaching and anxiety. Among the studies reviewed, few have structurally modelled digital competence as a higher-order construct (DigCompEdu) that predicts technological fatigue in compulsory education.

Within the framework of job demands and resources (JD-R) (Bakker and de Vries, 2020), job demands refer to aspects of work that require sustained cognitive or emotional effort, while personal resources represent the psychological capacities that help individuals cope with these demands. In digitally intensified educational environments, the continuous integration of ICT can be conceptualised as an increasing job demand. From this perspective, digital teaching competence can function as a personal resource that cushions the negative impact of technological demands on teachers' well-being.

Theoretical Contribution

Therefore, this study offers three main theoretical contributions to the literature on digital competence and technological stress in educational contexts.

Firstly, it reconceptualises digital teaching competence (DTC), as defined by the European Commission's DigCompEdu framework, not only as a pedagogical or technical construct, but as a personal psychosocial resource within the job demands-resources (JD-R) model. While previous research has linked digital competence to teaching quality and innovation, little attention has been paid to its potential buffering role against the negative effects of technology-intensified job demands. By positioning DTC as a protective factor against technological fatigue, this study extends its theoretical scope beyond teaching performance to work well-being.

Secondly, the study advances methodological rigour by modelling DTC as a second-order latent construct based on the DigCompEdu framework, integrating its six areas of competence into a hierarchical structural equation model. Although previous research has examined isolated

dimensions of digital competence or technological stress, few studies have structurally examined their interrelationships within a comprehensive SEM framework in compulsory education settings.

Thirdly, this research contributes contextually by focusing on active early childhood and primary school teachers, a population that tends to be underrepresented in studies modelling technological stress compared to samples from higher education. Given the accelerated digital transformation of compulsory education following the COVID-19 pandemic, it is particularly relevant to understand how digital competence works as a regulatory mechanism for cognitive fatigue.

This reconceptualisation helps bridge the gap between research on digital innovation and the literature on occupational health in the educational field.

Study Objective and Research Questions

For all these reasons, the objective of the study was to analyse the influence of Digital Teaching Competence (DTC) on cognitive fatigue derived from the use of ICT among early childhood and primary school teachers, simultaneously evaluating the determining role of sociodemographic and professional variables such as gender, age and teaching experience through a structural equation model.

In relation to the general objective, the following questions were posed, which guided and structured the research:

RQ1: To what extent does Digital Teaching Competence (DTC) act as a predictor and mitigator of cognitive fatigue in teachers?

RQ2: Are there significant differences in the perception of cognitive fatigue based on sociodemographic factors?

RQ3: How do years of service and professional experience influence the relationship between technological competence and psychological exhaustion among teachers?

RQ4: Which competence areas of the DigCompEdu framework show the strongest inverse association with the onset of technofatigue symptoms?

Methodology

A quantitative study has been developed, with a non-experimental, cross-sectional and ex post facto design (Hernández, Fernández, & Baptista, 2016). The scope of the research is correlational-causal, aimed at verifying hypotheses through structural equation modelling (SEM), which allows for the analysis of complex relationships between latent and observed variables (Dragan, & Topolsek, 2014).

Participants

The sample consisted of a total of 1,400 teachers (N=1,400) working in early childhood education and primary education in the autonomous community of Andalusia (Spain). To conduct the study, a non-probability convenience sample was used (Cochran & Díaz, 1980) through professional networks and educational centres.

In terms of sociodemographic data, the distribution of the sample reflected a balanced representation of Andalusian teachers by province and gender (see Table 1). The average age was approximately 43 years (SD = 9.6), ranging from 23 to 62 years, with an average of 17 years of professional experience.

Table 1. Socio-demographic data of the study sample

Variable	Mean	Standard Desviation
Gender	1,669	0,4705
Age	1,989	0,85657
Years of Service	2,994	1,7438

Instrument

Two validated instruments of high scientific reliability were used for data collection:

- Digital Competence in Teaching: The DigCompEdu Check-in questionnaire was used, in its version adapted into Spanish by Cabero-Almenara and Palacios-Rodríguez (2020). The instrument consists of 22 items distributed across six competency areas: Professional Commitment (DTC1), Digital Content (DTC2), Teaching and Learning (DTC3), Assessment and Feedback (DTC4), Student Empowerment (DTC5) and Facilitating Student Digital Competence (DTC6). It is a five-point Likert scale. For this study, the reliability analysis yielded a Cronbach's alpha of 0.947 ($\alpha=0.947$), which is ideal for proceeding with the analysis.

- Technostress (Anxiety and Fatigue): The dimensions of 'Anxiety' (4 items) and 'Cognitive Fatigue' (4 items) from the RED-TIC scale by Salanova et al. (2007) were used. The items assess the perception of exhaustion and emotional tension derived from the use of technological tools in teaching performance. This is a 7-point Likert scale (0 = Strongly disagree, 6 = Strongly agree). In this study, the adapted subscale showed high internal consistency ($\alpha=0.929$).

Procedure and ethics

The survey was administered online during the academic year (2024–2025). All participants were informed of the study's objective, and anonymity and confidentiality of data were guaranteed in accordance with the Helsinki Protocol. Teachers gave their informed consent prior to accessing the questionnaire.

Data analysis

The statistical analysis was structured in three phases:

a) Descriptive and reliability analysis: The means, standard deviations and internal consistency of the scales were calculated using McDonald's Omega coefficient and Cronbach's Alpha coefficient.

b) Structural Equation Modelling (SEM): "To assess the relationship between Digital Teaching Competence (DTC) and Fatigue (FAT), a Structural Equation Modelling (SEM) was used with AMOS v.24 software. A second-order model was chosen for TDC, structured through six first-order latent dimensions (DTC1-DTC6).

The estimation method used was Maximum Likelihood (ML). Prior to structural analysis, the model was refined by eliminating those items whose standardised factor loadings were less than .50 (specifically A4_I13 and A2_I6), thus ensuring convergent validity (Byrne, 2016). To improve the model fit, covariances were established between the error terms of items that shared semantic similarity within the same dimension (e23-e24 and e32-e33), following the modification indices. The goodness of fit was evaluated using the following indices: the chi-square/degrees of freedom ratio, the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (TLI). An RMSEA < .08 and CFI/TLI values close to .90 were considered optimal fit values.

Results

Prior to structural analysis, a Confirmatory Factor Analysis (CFA) was performed to validate the measurement model. The results indicated excellent internal consistency through McDonald's Omega coefficient, whose values ranged from .84 to .92 for all dimensions of DigCompEdu. Convergent validity was confirmed by the Mean Extracted Variance ($AVE > .50$), ensuring that the indicators adequately represent their latent variables.

In relation to descriptive statistics (Table 2), participants scored what could be described as average on dimensions DTC 1, DTC2, and DTC5. Dimension DTC6 stands out for its lower scores, followed by DC3 and DC4. In terms of the items corresponding to fatigue and stress (FAT), teachers obtained an average score. It should be noted, in this case, that there is a higher standard deviation index, which reflects greater variability in the responses obtained.

Tabla 2. Estadísticos descriptivos

Dimensión	Media	Desviación estándar	Asimetría	Curtosis
DTC1	3.2021	.7645	.112	-.095
DTC2	3.0435	.7908	.111	-.674
DTC3	2.7653	.9499	.352	-.719
DTC4	2.8870	.7750	.313	.436
DTC5	3.0509	.9343	-.061	-.523
DC6	2.4872	1.0176	.270	-.687
FAT	2.2663	1.4740	.235	-.696

Multivariate normality was assessed using Mardia's coefficient. Although slight deviations were observed, the values remained within acceptable limits for maximum likelihood estimation, given the large sample size ($N = 1400$).

Measurement model adjustment

The structural model was evaluated using various goodness-of-fit indices following the recommendations of Hu and Bentler (1999). After refining the model (eliminating items with loadings $< .50$ and establishing covariances between errors e23-e24 and e32-e33 as suggested by the modification indices), the results indicated a satisfactory fit of the data (see Table 3).

Due to the sensitivity of χ^2 to sample size ($\chi^2/df > 3$) ($N=1400$), absolute and comparative fit indices were prioritised. The RMSEA was .076 (90% CI: .074 - .078), falling below the critical threshold of .08. The CFI (0.912) and TLI (0.920) exceeded the conventional threshold of 0.90, indicating acceptable incremental fit. Considering the hierarchical structure of the model and the large sample size, the overall fit indices support the adequacy and stability of the proposed structural solution.

Table 3. Goodness-of-fit measures. Own elaboration.

Index	Values obtained	Criteria
Chi/df	4.377	< 5
GFI	0.898	≤ 0.90
RMSEA	0.076	< 0.80
NFI	0.908	≤ 0.90
CFI	0.912	≤ 0.90
TLI	0.920	≤ 0.90
AGFI	0.902	≤ 0.90

Note: df = degrees of freedom; GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; NFI = normalised fit index; CFI = comparative fit index; AGFI = adjusted goodness-of-fit index.

Consequently, the structural equation model obtained showed the connections between sociodemographic factors (gender, age, and years of service) and the different dimensions of DTC, as well as the construct of fatigue. All relationships between the different constructs are considered significant, except for those obtained by the sociodemographic variable years of service. Table 4 presents the parameter estimates obtained in the final model design.

Table 4. Estimates of the final model parameters. Own elaboration.

Association between variables	RW	SE	RC	p	SRW
Gender→DTC	-.278	.028	-10.117	***	-.287
Age→ DTC	-.082	.022	-3.675	***	-.154
Years of Service→ DTC	.007	.011	.680	.496	.028
DTC→ DTC1	1.000	0.05	22.645	***	.746
DTC→ DTC2	1.145	0.049	23.571	***	.759
DTC→ DTC3	1.422	.073	19.568	***	.944
DTC→ DTC4	1.655	0.071	23.288	***	.946
DTC→ DTC5	2.368	.105	22.567	***	.968
DTC→ DTC6	1.924	.085	22.658	***	.905
DTC→ FAT	-.442	.086	-5.130	***	-.149
Gender→FAT	.534	.080	6.678	***	-.185
Age→ FAT	.280	.066	4.222	***	.177
Years of Service→ FAT	-.061	.032	-1.875	.061	-.078

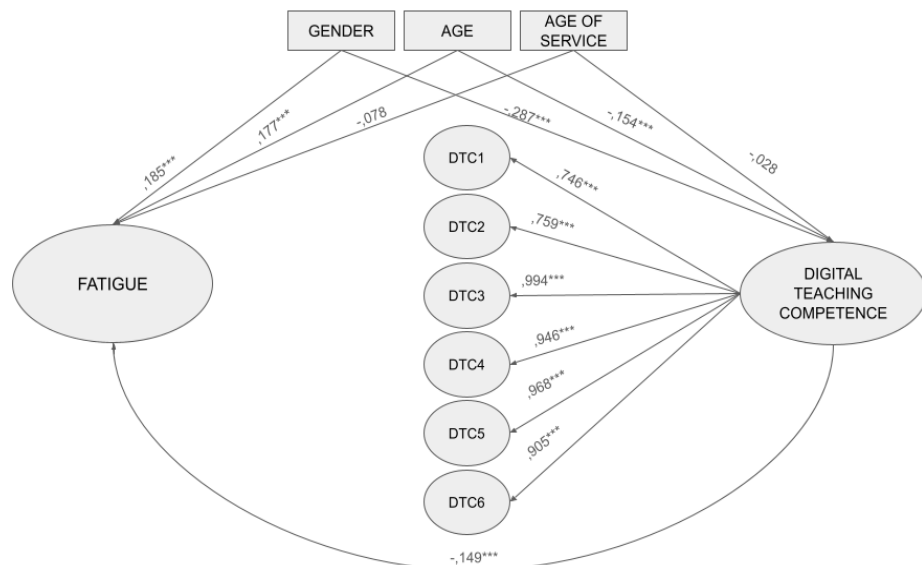


Figure 1. SEM model. Own elaboration.

Note: RW = regression weights; SE = standard error; CR = critical ratio; SRW = standardised regression weights; ***p<0.001; n = 1400

Finally, the graphical representation of the model confirms the predictive impact of DTC. In general terms, we can analyse the following results:

-Digital Teaching Competence has a negative and statistically significant effect on Fatigue ($B = -.149$; $p < .001$).

- Gender ($B = .185$; $p < .001$) and Age ($B = .177$; $p < .001$) are positively associated with higher levels of fatigue. In contrast, Years of Service showed a slight but significant inverse relationship ($B = -.078$; $p < .01$).

- The first-order dimensions showed very high factor loadings on the general DTC factor, especially DTC3 (.994) and DTC5 (.968), reinforcing the validity of the hierarchical model.

Discussion

The aim of this study was to analyse the relationship between Digital Teaching Competence (DTC) and cognitive fatigue resulting from the use of ICT, also considering the role of sociodemographic variables. The results obtained provide a structured response to the four research questions posed.

RQ1: To what extent does Digital Teaching Competence (DTC) act as a predictor and mitigator of cognitive fatigue in teachers?

The results of the structural model indicate that CDD is negatively and statistically significantly associated with cognitive fatigue ($\beta = -.149$; $p < .001$). Although the effect size can be considered moderate, its relevance is consistent from both a practical and theoretical point of view.

This finding supports the idea that digital competence should not be understood solely as a set of technical skills, but as a professional resource that reduces the perception of cognitive overload associated with intensive use of technologies (Aznar et al., 2025). Teachers with higher levels of DTC are likely to experience a greater sense of control, less uncertainty about digital tools, and greater operational fluency, which reduces the cognitive effort required in their daily performance.

This result is consistent with previous research that has indicated that the perception of technological competence is inversely related to indicators of technostress and emotional exhaustion (Li, Chen, & Zhang, 2026; Dogan, & Arslan 2026). In interpretive terms, the data suggest that strengthening TCD can indirectly contribute to teacher well-being, not only by improving pedagogical quality, but also by reducing vulnerability to cognitive fatigue in digitalised contexts.

RQ2: Are there significant differences in the perception of cognitive fatigue based on sociodemographic factors?

The results show that both age ($\beta = .177$; $p < .001$) and gender ($\beta = .185$; $p < .001$) are positively associated with higher levels of cognitive fatigue. These effects, although moderate in magnitude, are consistent and statistically robust.

In relation to age, the data suggest that older teachers tend to report higher levels of technological exhaustion. This association can be interpreted in terms of the digital generation gap, differences in initial educational trajectories, or less early exposure to technological environments (Ralda, Lázaro, & Holgado, 2024). However, the authors of this manuscript insist on avoiding deterministic interpretations: age does not imply lower competence per se, but may reflect cumulative inequalities in opportunities for training and digital updating.

With regard to gender, the results show significant differences in fatigue levels, which could be linked to structural dynamics such as the double workload, greater responsibilities for work-life balance, or differences in self-perceived technological competence described in previous studies (Fernández & Montenegro, 2023; Fernández & Silva, 2022). These findings invite us to analyse the phenomenon from an equity perspective, rather than from an individualistic view of technological performance.

Overall, the data confirm that the experience of techno-fatigue is not homogeneous, but is modulated by structural variables that shape teachers' career trajectories.

RQ3: How do years of service and professional experience influence the relationship between technological competence and psychological exhaustion among teachers?

Contrary to expectations, years of service did not show a significant relationship with CDD ($\beta = .028$; $p = .496$) or cognitive fatigue ($\beta = -.078$; $p = .061$). This result is particularly interesting, as it challenges the idea that accumulated experience automatically acts as a protective factor against technological burnout.

One possible interpretation is that professional experience does not necessarily guarantee continuous digital updating. In contexts of rapid technological transformation, seniority may not translate into an adaptive advantage if it is not accompanied by specific training and ongoing skills development.

Likewise, the fact that years of service do not significantly increase fatigue suggests that technological burnout does not depend exclusively on time in the profession, but on variables more directly related to the perception of competence and the management of digital demands (Zhao, & Zeng, 2024; Trujillo et al., 2020).

This finding adds an important nuance to the literature, indicating that the critical variable is not experience itself, but rather the effective digital competence developed throughout one's professional career.

RQ4: Which competency areas of the DigCompEdu framework show the strongest inverse association with the onset of technostress symptoms?

In relation to the characterisation of digital competence, the second-order model has revealed that the dimensions of the DigCompEdu framework do not contribute uniformly to the configuration of the overall construct. The results indicate that the areas of Teaching and Learning (CD3) and Student Empowerment (CD5) have the highest factor loadings. This finding is highly relevant, as it suggests that the core of digital competence in teaching does not lie in the instrumental mastery of tools, but rather in the ability of teachers to orchestrate pedagogical strategies and promote student autonomy in digital environments (Cid, Aznar, Gómez-García, Maldonado, 2025).

From the perspective of the Job Demands and Resources (JD-R) model, this dimensional hierarchy allows us to interpret why CDD acts as a protective mechanism against cognitive fatigue (Bakker et al, 2023). As digital pedagogy (CD3) is the factor with the highest saturation, one could infer that a coherent instructional design gives meaning to the use of technology, reducing the cognitive load derived from improvisation or information overload. Likewise, the critical weight of student empowerment (CD5) suggests that the most effective digital competence for mitigating exhaustion is that which promotes inclusion and accessibility. By promoting student autonomy through digital resources, teachers could experience a reduction in the demands for constant support, thus cushioning levels of emotional stress and fatigue.

Therefore, the prevention of techno-fatigue seems to depend less on administrative skills or professional commitment (CD1) and more on the ability to transform classroom practice into a digitally efficient and student-centred process.

Conclusions

This study confirms that Digital Teaching Competence (DTC) is negatively and significantly associated with cognitive fatigue resulting from the use of technology in early childhood and primary education. Although the effect size is moderate, the results show that digital competence not only affects teaching quality, but is also linked to teachers' professional well-being in highly digitised contexts.

Likewise, age and gender showed significant associations with higher levels of technostress, suggesting that the experience of technological burnout is not homogeneous and may be conditioned by structural factors related to educational trajectories and inequalities in access to digital capital. In contrast, years of service did not emerge as a significant predictor, indicating that professional seniority does not in itself guarantee greater adaptation to changing technological environments.

From a conceptual perspective, the findings broaden our understanding of teachers' digital competence, positioning it not only as an indicator of pedagogical innovation, but also as a variable associated with the regulation of cognitive load in digitised educational environments. This reinterpretation adds an important nuance to the contemporary debate on educational digitisation by integrating pedagogical and psychosocial dimensions.

In practical terms, the results reinforce the need to design continuing education programmes that prioritise the meaningful pedagogical integration of technology and not exclusively the instrumental learning of tools. Likewise, educational policies aimed at digital transformation should incorporate strategies to prevent technological burnout as part of teacher wellbeing plans. Finally, future longitudinal and cross-cultural research will allow for a deeper understanding of the directionality of the observed relationships and an evaluation of the stability of the model in different educational contexts, contributing to a more comprehensive understanding of the psychosocial effects of digitalisation on the teaching profession.

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