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Assessment and Feedback in the Digital Age: Impact on the Facilitation of Students' Digital Competencies

Evaluación y retroalimentación en la era digital: Impacto en la facilitación de competencias digitales de los estudiantes

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Abstract

Introduction: In contemporary higher education, assessment and feedback have ascended to a position of paramount importance, establishing themselves as quintessential elements in cultivating digital competencies among students. This study endeavours to scrutinize how these practices have reconfigured pedagogical dynamics, underscoring the imperative to adopt a continuous, student-centric approach.

Method: The research employed a quantitative descriptive-transversal methodology, administering the ACU-CODI questionnaire to a representative sample of 3,309 students spanning diverse educational disciplines within Andalusian universities. The participants ranged in age from 18 to 50 years.

Results: The findings elucidate that students engaging in digital assessment processes evince marked enhancements in their technological prowess and information processing capabilities, alongside augmented self-regulation and critical thinking skills. Moreover, a positive correlation is established between the calibre of digital feedback and the cultivation of essential competencies, such as problem-solving acumen.

Conclusions: This study culminates by accentuating the criticality of ongoing, adaptive teacher training, as well as the exigency to engineer learning environments that seamlessly integrate efficacious digital tools, thereby equipping students to navigate the multifaceted challenges of the 21st century.

Keywords: digital assessment, feedback, students, digital competencies, quantitative methodology.

Resumen

Introducción: En la actualidad, la evaluación y retroalimentación han adquirido un papel preponderante en el ámbito de la educación superior, constituyéndose en elementos fundamentales para el desarrollo de competencias digitales entre el estudiantado. Este estudio se propone analizar cómo estas prácticas han reconfigurado las dinámicas pedagógicas, destacando la necesidad de adoptar un enfoque continuo y centrado en el estudiante.

Método: Se empleó una metodología cuantitativa descriptivo-transversal, aplicando el cuestionario ACU-CODI a una muestra representativa de 3.309 estudiantes de diversas disciplinas educativas en universidades andaluzas, con edades comprendidas entre 18 y 50 años.

Resultados: Los hallazgos revelan que los discentes que participan en procesos de evaluación digital experimentan mejoras significativas en sus habilidades tecnológicas y en su capacidad para procesar información, así como un incremento en la autorregulación y el pensamiento crítico. Asimismo, se establece una mejora positiva entre la calidad de la retroalimentación digital y el desarrollo de competencias esenciales, como la resolución de problemas.

Conclusiones: Este estudio concluye subrayando la importancia de una formación docente continua y adaptativa, así como la necesidad de crear entornos de aprendizaje que integren herramientas digitales efectivas para preparar a los estudiantes ante los retos del siglo XXI.

Palabras clave: evaluación digital, retroalimentación, estudiantes, competencias digitales, metodología cuantitativa.

Introduction

In the current landscape of higher education, the digital era has catalysed a significant transformation in assessment and feedback processes, profoundly impacting the manner in which students' digital competencies are developed. This evolution has not only redefined pedagogical practices but has also introduced new challenges and opportunities in the cultivation of essential skills for the 21st century.

Digital assessment and feedback

The digital era has profoundly revolutionized the conception and execution of assessment and feedback within the educational sphere. In this regard, on the one hand García-Peñalvo et al. (2021) argue that digital assessment transcends the mere utilization of technological tools, representing a paradigm shift in the understanding of the evaluative process. This new approach is characterized by being more continuous, formative, and student-centred, marking a clear evolution from traditional methods. Complementing this perspective, Boud and Dawson (2021) highlight the necessity of developing assessment practices that promote self-regulation and metacognition among students, leveraging the potential offered by digital technologies.

Innovative practices are also emerging in the field of digital assessment. For instance, Tsai et al. (2020) underscore the role of gamification and augmented reality as tools that enable the evaluation of complex competencies in more authentic and meaningful contexts. In parallel, Timmis et al. (2022) contend that digital assessment significantly contributes to the development of digital citizenship by exposing students to ethical and responsible practices in technology use. Additionally, a study conducted by Sánchez-Cruzado et al. (2021) reveals that students engaged in digital assessment processes demonstrate a significant improvement in their ability to utilize technological tools and process information in digital environments.

On the other hand, digital feedback has also experienced a significant transformation. In line with this, Martínez-Solana et al. (2020) emphasize the significance of immediate and personalized feedback facilitated by digital tools. According to the authors, this immediacy fosters more effective learning tailored to the individual needs of each student. Moreover, Redecker and Punie (2019) point out the growing relevance of learning analytics in providing more precise and timely feedback. This observation is reinforced by the work of Gikandi and Morrow (2019), who argue that well-designed digital feedback can foster critical thinking and problem-solving skills in digital contexts.

In this perspective, the dialogic nature of feedback has been increasingly recognized. Carless and Boud (2018) emphasize feedback as a two-way process that promotes student autonomy and active engagement with learning. This reconceptualization of feedback aligns with the broader goals of digital education by integrating both pedagogical and technological dimensions.

The impact of these advancements in digital assessment and feedback on learning and the development of digital competencies is noteworthy. Collectively, these findings underscore the crucial importance of digital assessment and feedback in contemporary education, not merely as tools for measuring learning but as catalysts for developing essential skills in the digital age.

Digital Learning Ecosystems and Educational Resources: Transforming the Educational Ecosystem

The ecology of digital learning and digital educational resources is profoundly reconfiguring the contemporary educational ecosystem. This transformation encompasses the complex interactions among various elements of the learning environment, as well as the integration of digital tools and content into educational processes.

At the core of this transformation, Castañeda and Selwyn (2018) argue that digital technologies are not merely tools; they shape new spaces and forms of learning. This ecological perspective allows us to understand how the introduction of digital assessment and feedback technologies is reshaping power relations and institutional dynamics in higher education, as noted by Williamson et al. (2020). These changes pose new challenges and opportunities for educational management and teacher training.

The implications of this digital ecology are particularly significant in the realm of assessment and the development of digital competencies. Gašević et al. (2019) highlight how learning analytics enables a deeper understanding of competency development across various contexts and over time. However, Marín et al. (2020) caution about the need to consider ethical and privacy aspects in the use of data for digital assessment, emphasizing the importance of developing ethical frameworks and institutional policies that ensure responsible use of technology.

In this evolving digital ecosystem, educational resources play a crucial role. Mercader and Gairín (2020) provide a useful classification of these resources into categories of information, collaboration, and learning, each with specific characteristics tailored to different pedagogical objectives and contexts. Complementing this view, Rodríguez-García et al. (2019) underscore the growing importance of Open Educational Resources (OER) in higher education, which promote more equitable access to quality educational materials.

The effective integration of these digital resources into assessment processes and the facilitation of digital competencies represents a significant challenge. Cabero-Almenara et al. (2021) emphasize the need for robust instructional design that aligns learning objectives, activities, and assessment. Meanwhile, Tondeur et al. (2020) highlight the critical importance of teacher training in the pedagogical use of digital resources, arguing that mere availability of technology does not guarantee its effective use in the classroom.

Together, this ecological perspective on digital learning and educational resources provides a holistic view of how technologies are transforming not only teaching tools and methods but also the fundamental structures and dynamics of the educational ecosystem. This approach underscores the need for continuous adaptation and comprehensive training for both educators and students to effectively navigate this ever-evolving educational landscape.

Digital Competence Framework: Facilitating the Development of Digital Competencies in Higher Education

Digital competencies have become a fundamental element in higher education, reflecting the growing importance of digital literacy in contemporary society. The DigComp 2.2 framework, proposed by Vuorikari et al. (2022), establishes five main areas

of digital competencies: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Various authors, such as Cabero-Almenara and Palacios-Rodríguez (2020) and Falloon (2020), emphasize the need to integrate these competencies transversally into university curricula, adapting them to the specific needs of each discipline and professional profile. To effectively develop these competencies, innovative pedagogical strategies are proposed, such as project-based learning, technology-mediated collaborative learning, and flipped learning (Gómez-Trigueros et al., 2021; Pérez-Escoda & García-Ruiz, 2021).

The DigCompEdu framework, on the other hand, specifically focuses on the digital competencies of educators. Developed by Redecker (2017) and subsequently updated, this framework identifies six areas of digital competencies for teachers: professional engagement, digital resources, teaching and learning, assessment, empowering students, and facilitating students' digital competence. DigCompEdu provides guidance for the professional development of educators in the use of digital technologies, encompassing everything from planning and designing learning experiences to assessing and promoting students' digital autonomy. This framework complements the general DigComp framework by offering a specific perspective for the education sector and helping teachers effectively integrate digital technologies into their pedagogical practice.

In the context of this article, we will focus specifically on two crucial areas of the DigCompEdu framework: assessment and facilitation of students' digital competencies. Assessment in the digital environment involves not only the use of technological tools to measure learning but also the implementation of strategies that encourage self-assessment and critical thinking among students regarding their digital skills. On the other hand, facilitating digital competencies refers to educators' ability to design and implement learning activities that effectively develop these skills in students, preparing them for the challenges of an increasingly digitized world.

Our focus on these areas seeks to explore how educators can leverage digital technologies to assess more effectively and foster the development of digital competencies in their students. This analysis leads us to propose the following objectives that will guide our research on the impact of digital assessment practices on facilitating students' digital competencies in higher education:

1. Examine the multidimensional structure of teachers' digital competencies, with particular emphasis on the domains of assessment, feedback, and facilitation of learning, in order to identify critical factors that shape these competencies in today's digital educational ecosystem.
2. Analyse the dynamics of interaction among various dimensions of teachers' digital competence, exploring how these manifests in pedagogical practices and how they influence educators' capacity to promote the development of digital skills in their students.
3. Elucidate the complex interrelationship between teachers' digital competencies in assessment and feedback and their influence on educators' ability to facilitate the development of digital competencies in students, considering the context of digital transformation in contemporary education.

Method

In accordance with the established objectives, a quantitative methodology of a descriptive-cross-sectional nature has been implemented, based on the probabilistic analysis of a representative sample. This approach allows for the acquisition of objective and precise results, facilitating a thorough exploration of the variables under study and providing a reliable view of the key interrelationships in technological adaptation within the current educational context.

Participants

The target population for this research consists of a total of 3,309 students, all enrolled in various higher education programs aimed at preparing future educators and understood as active agents in the development and application of digital competences. These include degrees in Primary Education, Early Childhood Education, and Pedagogy, as well as the Master's Degree in Secondary Education and Baccalaureate Teaching. The participants are enrolled in three universities in Eastern Andalusia: the University of Jaen, the University of Granada, and the University of Almería.

In terms of gender, the sample presents an uneven yet representative distribution: there are 1,145 men (34.6%) and 2,164 women (65.4%), reflecting the general trend observed in education programs. Regarding the age of the participants, the range spans from 18 to 50 years; however, the majority (92.3%) fall within the age group of 18 to 25 years, indicating that the sample is primarily composed of students following a traditional academic path. The average age is approximately 22 years, with a standard deviation of ±1.043 years, suggesting a relatively homogeneous distribution around this mean.

Instruments

The instrument used in this research is an adaptation known as ACU-CODI, which is part of a broader study. This ad hoc scale has been validated through expert judgment to ensure its content relevance and clarity, and it has demonstrated excellent psychometric properties, including a notable Cronbach's Alpha and a factor analysis that supports its robustness. . The questionnaire is divided into three main sections: sociodemographic factors, the ACUTIC study, and the DIGCOMPEDU study.

The ACUTIC questionnaire (Questionnaire for the Study of Attitude, Knowledge, and Use of ICT), developed by Mirete et al. (2015), exhibits a high degree of reliability with a Cronbach's Alpha of .891. It consists of 31 items organized into three dimensions: attitude towards ICT (7 items), training and knowledge about ICT (12 items), and use of ICT (12 items). On the other hand, the "DigCompEdu Check-in" study, validated by Ghomi and Redecker (2018), is based on the European Framework for Digital Competence for Educators, DigCompEdu. This framework encompasses six competency areas: Professional Engagement, Digital Resources, Digital Pedagogy, Assessment and Feedback, Empowering Students, and Facilitating Students' Digital Competence. It consists of 22 items and has shown high reliability with a Cronbach's Alpha of .960 and a McDonald's Omega of .964. It is important to highlight that this article specifically focuses on the dimensions related to assessment and the facilitation of digital competencies among students—key aspects that are fundamental to our research on technological adaptation in the educational field.

Procedure and data analysis

For the development of the research and the collection of information, strict ethical protocols were followed in accordance with national and international regulations concerning research involving human subjects. The handling of all data was conducted in strict compliance with the General Data Protection Regulation (GDPR) of the EU and the Organic Law on Data Protection and Guarantee of Digital Rights in Spain, ensuring the anonymity and confidentiality of participants' responses at all times.

The administration of the instrument was carried out individually through the Google Forms platform. At the beginning of the questionnaire, a pre-test was applied to assess participants' initial self-perception of their digital competence. After completing the main sections of the instrument, including items related to digital practices, assessment, and facilitation, a post-test was conducted to reevaluate any changes in their self-perception. The researchers provided a detailed explanation of the study's purpose and requested voluntary participation, adhering rigorously to the ethical principles established in the Declaration of Helsinki (World Medical Association, 2013).

Regarding data analysis, the Hot-Deck method was applied to minimize potential biases (Lorenzo-Seva & Van-Ginkel, 2016), and the validity and reliability of the instrument were evaluated through Confirmatory Factor Analysis. For statistical processing, SPSS AMOS 25 and Jamovi (The jamovi Project, 2020) were used, allowing for descriptive statistics, Pearson correlations, and ANOVAs. This analysis focuses on examining the correlations among various dimensions of the study, providing a comprehensive view of the interrelationships between the factors investigated.

Results

Table 1

Descriptive analysis

		Dimension D. Professional Engagement	Dimension E. Digital Resources	Dimension F. Digital Pedagogy	Dimension G. Assessment and Feedback	Dimension H. Empowering Students	Dimension I. Facilitating Digital Competence
N	Valid	3309	3309	3309	3309	3309	3309
	Lost	0	0	0	0	0	0
Mean		2.9056	3.2126	3.0285	2.8900	3.0280	2.8210
Median		3.0000	3.3333	3.0000	3.0000	3.0000	3.0000
Std. Deviation		.77147	.87585	.97508	.83535	.90480	1.09049
Variance		.595	.767	.951	.698	.819	1.189
Skewness		-.082	-.175	-.112	.092	.029	-.070
Standard error of Skewness		.043	.043	.043	.043	.043	.043
Kurtosis		-.888	-.943	-.926	-.878	-.948	-1.123
Standard error of kurtosis		.085	.085	.085	.085	.085	.085

After a thorough analysis of the provided data, regarding the central tendencies, it is observed that the dimension "Digital Resources" achieves the highest mean score (M=3.2126), followed by "Digital Pedagogy" and "Empowering Students," both with very similar means (M=3.0285 and M=3.0280, respectively). In contrast, the dimension "Facilitating Digital Competence" presents the lowest mean (M=2.8210), closely followed by "Assessment and Feedback" (M=2.8900) and "Professional Engagement" (M=2.9056). Although these differences are subtle, they indicate areas that may require greater attention in teacher professional development.

The variability of responses, reflected in the standard deviations, shows interesting patterns. The dimension "Facilitating Digital Competence" exhibits the greatest dispersion (SD=1.09049), suggesting considerable heterogeneity in educators' abilities to promote this competence. On the other hand, "Professional Engagement" shows the least variability (SD= .77147), indicating greater consistency in this aspect among participants.

Regarding the shape of the distributions, skewness coefficients close to zero (ranging from - .175 to .092) indicate approximately symmetric distributions for all dimensions. However, the negative kurtosis in all cases (from -.878 to -1.123) reveals platykurtic distributions, with a greater data dispersion than expected in a normal distribution. This phenomenon is particularly pronounced in the dimension "Facilitating Digital Competence" (kurtosis = -1.123).

These statistical results provide a solid foundation for understanding the current state of digital competencies in the educational sector, highlighting areas of relative strength, such as digital resources, and areas that could benefit from specific interventions, such as facilitating digital competencies and assessment through technological tools.

Table 2

Correlational analysis

		Dimension D. Professional Engagement	Dimension E. Digital Resources	Dimension F. Digital Pedagogy	Dimension G. Assessment and Feedback	Dimension H. Empowering Students	Dimension I. Facilitating Digital Competence
Dimension D. Professional Engagement	Pearson Correlation	1	.661**	.797**	.759**	.635**	.629**
	Sig. (bilateral)		.000	.000	.000	.000	.000
	N	3309	3309	3309	3309	3309	3309
Dimension E. Digital Resources	Pearson Correlation	.661**	1	.732**	.636**	.720**	.602**
	Sig. (bilateral)	.000		.000	.000	.000	.000
	N	3309	3309	3309	3309	3309	3309
Dimension F. Digital Pedagogy	Pearson Correlation	.797**	.732**	1	.863**	.824**	.835**
	Sig. (bilateral)	.000	.000		.000	.000	.000
	N	3309	3309	3309	3309	3309	3309

		Dimension D. Professional Engagement	Dimension E. Digital Resources	Dimension F. Digital Pedagogy	Dimension G. Assessment and Feedback	Dimension H. Empowering Students	Dimension I. Facilitating Digital Competence
Dimension G. Assessment and Feedback	Pearson Correlation	.759**	.636**	.863**	1	.852**	.738**
	Sig. (bilateral)	.000	.000	.000		.000	.000
	N	3309	3309	3309	3309	3309	3309
Dimension H. Empowering Students	Pearson Correlation	.635**	.720**	.824**	.852**	1	.741**
	Sig. (bilateral)	.000	.000	.000	.000		.000
	N	3309	3309	3309	3309	3309	3309
Dimension I. Facilitating Digital Competence	Pearson Correlation	.629**	.602**	.835**	.738**	.741**	1
	Sig. (bilateral)	.000	.000	.000	.000	.000	
	N	3309	3309	3309	3309	3309	3309

Note. **The correlation is significant at the level of .01. (bilateral).

The correlational analysis of the six dimensions of digital competence in the educational field reveals a pattern of significant and robust interrelationships, providing a comprehensive view of the underlying structure of these competencies.

Firstly, it is noteworthy that all correlations are statistically significant ($p < .001$) and positive, with magnitudes ranging from moderate to high. This finding suggests a strong interconnection between the different facets of teachers' digital competence, indicating that development in one dimension tends to be associated with improvements in others.

The strongest correlations ($r > .800$) are observed between the dimension "Digital Pedagogy" and three other dimensions: "Assessment and Feedback" ($r = .863$), "Empowering Students" ($r = .824$), and "Facilitating Digital Competence" ($r = .835$). This underscores the central role that digital pedagogy plays in the effective integration of technologies into the educational process. Additionally, the strong correlation between "Assessment and Feedback" and "Empowering Students" ($r = .852$) suggests a close relationship between these pedagogical practices.

Regarding the focal dimensions of the study, "Assessment and Feedback" (Dimension G) shows particularly strong correlations with "Digital Pedagogy" ($r = .863$) and "Empowering Students" ($r = .852$), while its weakest correlation is with "Digital Resources" ($r = .636$). Meanwhile, "Facilitating Digital Competence" (Dimension I) presents its strongest correlation with "Digital Pedagogy" ($r = .835$) and its weakest with "Digital Resources" ($r = .602$).

It is notable that the dimension "Digital Resources" tends to show relatively lower correlations with other dimensions, although they remain moderate to high (between $r = .602$ and $r = .732$). This could indicate that while digital resources are important, their

mere availability does not necessarily guarantee a high level of competence in other areas.

In conclusion, this correlational analysis provides empirical evidence of the interconnected nature of digital competencies in education, offering a solid foundation for the development of comprehensive strategies to enhance teachers' digital competence.

Table 3

Inter-subject Effects Tests

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncentrality Parameter	Observed Power
Corrected model	Dimension G.	1927.389[a]	4	481.847	4179.143	.000	.835	16716.572	1.000
	Dimension I.	2793.706[b]	4	698.426	2024.157	.000	.710	8096.630	1.000
Intercept	Dimension G.	8.482	1	8.482	73.563	.000	.022	73.563	1.000
	Dimension I.	.143	1	.143	.415	.520	.000	.415	.099
DIM_D	Dimension G.	54.828	1	54.828	475.529	.000	.126	475.529	1.000
	Dimension I.	8.462	1	8.462	24.524	.000	.007	24.524	.999
DIM_E	Dimension G.	25.080	1	25.080	217.524	.000	.062	217.524	1.000
	Dimension I.	4.141	1	4.141	12.000	.001	.004	12.000	.934
DIM_F	Dimension G.	53.760	1	53.760	466.269	.000	.124	466.269	1.000
	Dimension I.	467.285	1	467.285	1354.271	.000	.291	1354.271	1.000
DIM_H	Dimension G.	176.423	1	176.423	1530.143	.000	.317	1530.143	1.000
	Dimension I.	35.559	1	35.559	103.056	.000	.030	103.056	1.000
Error	Dimension G.	380.945	3304	.115					
	Dimension I.	1140.030	3304	.345					
Total	Dimension G.	29945.375	3309						
	Dimension I.	30267.520	3309						

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncentrality Parameter	Observed Power
Corrected total	Dimension G.	2308.334	3308						
	Dimension I.	3933.736	3308						

Note. Dimension G. Assessment and Feedback/ Dimension I. Facilitating Digital Competence
a. R squared = .835 (adjusted R squared = .835)
b. R squared = .710 (adjusted R squared = .710)
c. Calculated using alpha = .05

The multivariate analysis of Dimensions G (Assessment and Feedback) and I (Facilitating Digital Competence) provides an enlightening perspective on the structure and interrelationships of digital competencies in the educational field. The results obtained through intersubject effects tests reveal complex and significant patterns that warrant detailed consideration.

Firstly, it is imperative to highlight the statistical robustness of both models. The model corresponding to Dimension G exhibits exceptional fit, with a coefficient of determination (R^2) of .835, indicating that 83.5% of the variance in assessment and feedback is explained by the included predictor variables. Meanwhile, the model for Dimension I, although slightly lower, also shows substantial fit, with an R^2 of .710. The statistical significance of both models ($p < .001$) and the observed power of 1.000 in most effects underscore the reliability and validity of these findings.

When examining the specific effects of predictor variables, differentiated patterns are observed between the two dimensions. For Dimension G, the variable "Empowering Students" emerges as the most potent predictor, with a considerable effect size (η^2 partial = .317), followed by "Professional Engagement" (η^2 partial = .126) and "Digital Pedagogy" (η^2 partial = .124). In contrast, for Dimension I, "Digital Pedagogy" stands out as the dominant factor (η^2 partial = .291), while the other variables show substantially smaller effects.

This disparity in the relative importance of predictors between the two dimensions is particularly revealing. It suggests that the competencies necessary for effective assessment and feedback are more closely linked to the ability to empower students, while the facilitation of digital competence relies more heavily on teachers' digital pedagogical skills. This distinction has significant implications for the design of training programs and professional development for educators.

It is also noteworthy that all predictor variables consistently show statistical significance in both models ($p < .001$ in all cases, except $p = .001$ for "Digital Resources" in Dimension I). However, the magnitude of these effects varies considerably, ranging from large to very small effects, highlighting the complexity of interrelationships among different facets of teachers' digital competence.

In conclusion, this multivariate analysis provides robust empirical evidence regarding the multidimensional structure of digital competencies in education. The findings suggest that while there is a significant interconnection among different dimensions, each is influenced by a unique set of predictive factors.

Table 4

Parameter estimates

Dependent Variable	Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared	Noncentrality Parameter	Observed Power
						Lower limit	Upper limit			
Dimension G. Assessment and Feedback	Intercept	.221	.026	8.577	.000	.171	.272	.022	8.577	1.000
	DIM_D	.284	.013	21.807	.000	.258	.309	.126	21.807	1.000
	DIM_E	-.157	.011	-14.749	.000	-.178	-.136	.062	14.749	1.000
	DIM_F	.299	.014	21.593	.000	.272	.327	.124	21.593	1.000
	DIM_H	.476	.012	39.117	.000	.452	.500	.317	39.117	1.000
Dimension I. Facilitating Digital Competence	Intercept	.029	.045	.644	.520	-.059	.116	.000	.644	.099
	DIM_D	-.111	.023	-4.952	.000	-.156	-.067	.007	4.952	.999
	DIM_E	-.064	.018	-3.464	.001	-.100	-.028	.004	3.464	.934
	DIM_F	.883	.024	36.800	.000	.836	.930	.291	36.800	1.000
	DIM_H	.214	.021	10.152	.000	.172	.255	.030	10.152	1.000

Note. a. Calculated using alpha= .05

The multivariate analysis of the dimensions of teachers' digital competence reveals a complex and highly significant structure in two fundamental dimensions: Assessment and Feedback (Dimension G) and Facilitating Digital Competence (Dimension I).

The developed statistical models provide precise information about the interrelationship of different predictor variables. For Dimension G, the equation [G = .221 + .284(DIM_D) - .157(DIM_E) + .299(DIM_F) + .476(DIM_H)] shows a significant intercept of 0.221, indicating a baseline starting point in assessment competencies.

The most influential predictor in this model is "Empowering Students" (DIM_H), with a coefficient of .476 and an effect size of .317, followed by "Digital Pedagogy" (DIM_F) with .299 and "Professional Engagement" (DIM_D) with .284. Particularly interesting is the negative effect of "Digital Resources" (DIM_E) with - .157, suggesting a potentially complex inverse relationship.

In contrast, the model for Dimension I [I = .029 - .111(DIM_D) - .064(DIM_E) + .883(DIM_F) + .214(DIM_H)] presents a practically neutral intercept of .029. Here, "Digital Pedagogy" emerges as the absolute dominant predictor, with a coefficient of .883 and an explanatory effect of .291.

The results reveal substantial differences between both models. While Dimension G shows more balanced effects among predictors, Dimension I is clearly determined by digital pedagogy. The direction of effects varies significantly: in the first model, three predictors are positive; in the second, two are positive and two negative. Specifically, in Dimension G, "Empowering Students" (DIM_H, B = .476, η^2 partial = .317), "Digital Pedagogy" (DIM_F, B = .299, η^2 partial = .124), and "Professional Engagement" (DIM_D, B = .284, η^2 partial = .126) show positive effects, while "Digital Resources" (DIM_E, B = - .157, η^2 partial = .062) presents a negative effect. In contrast, in Dimension I, "Digital Pedagogy" dominates with a coefficient of .883 (η^2 partial = .291), followed by a

smaller positive effect from "Empowering Students" (B = .214, η^2 partial = .030), while "Professional Engagement" (B = - .111, η^2 partial = .007) and "Digital Resources" (B = - .064, η^2 partial = .004) show negative effects. These differences in magnitude and direction of effects suggest that competencies in assessment and feedback depend on a more complex interaction of factors, while the facilitation of digital competencies is primarily determined by teachers' digital pedagogical skills.

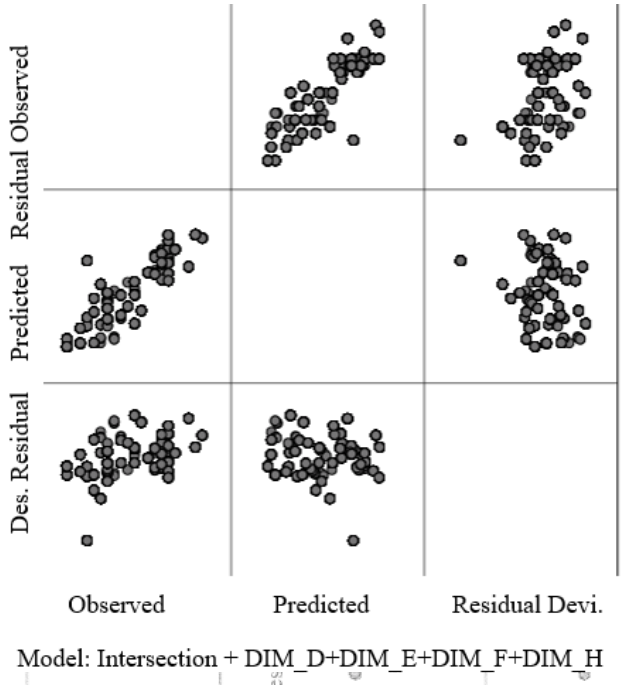
These findings have profound implications for teacher training. They suggest that competencies in assessment and feedback depend more uniformly on multiple dimensions of digital competence, with particular emphasis on student empowerment. The facilitation of digital competencies, on the other hand, appears to rely almost exclusively on digital pedagogical skills.

Statistical significance is consistently high ($p < .001$) across virtually all predictors, with 95% confidence intervals reinforcing the robustness of the models. The observed power of 1.000 in most effects ensures the reliability of these estimates.

In summary, this analysis not only provides a detailed overview of teachers' digital competencies but also offers a conceptual framework for understanding their complexity, variability, and potential for professional development in the digital age.

Figure 1

Dependent Variable: Dimension G. Assessment and Feedback



The analysis of the scatter matrix graph provides a valuable visual representation of the relationships between Dimension G (Assessment and Feedback) and its predictors (DIM_D, DIM_E, DIM_F, DIM_H). This visualization corroborates and enriches the findings from the previous statistical analysis.

The matrix displays consistent and homogeneous dispersion patterns, with no evidence of extreme outliers that could distort the observed relationships. This characteristic reinforces the robustness of the results obtained in the regression model.

The relationship between Dimension G and the predictor "Empowering Students" (DIM_H) stands out due to its strong positive association, exhibiting a well-defined linear pattern with the least dispersion of points. This visual finding validates the highest coefficient obtained in the model (B = .476, η^2 partial = .317), highlighting the critical importance of student empowerment in assessment and feedback competencies.

The association between Dimension G and "Digital Pedagogy" (DIM_F) shows a consistent positive relationship, with a moderately strong linear pattern and moderate dispersion. This observation supports the significant positive coefficient found (B = .299, η^2 partial = .124), confirming the relevance of digital pedagogical skills in the evaluative process.

The relationship between Dimension G and "Professional Engagement" (DIM_D) presents a moderate positive trend, characterized by a defined linear pattern and moderate dispersion. This visualization is consistent with the coefficient obtained (B = .284, η^2 partial = .126), reaffirming the contribution of teacher engagement in assessment practices.

Particularly interesting is the relationship between Dimension G and "Digital Resources" (DIM_E), which shows a more complex and less defined pattern with greater dispersion. This visual complexity justifies the negative coefficient found (B = - .157, η^2 partial = .062), suggesting a subtle but significant inverse relationship that warrants further analysis.

From a methodological perspective, the predominance of linear relationships in the graph validates the use of the linear model employed in the analysis. Additionally, the relatively constant dispersion across different relationships suggests compliance with the assumption of homoscedasticity, strengthening the reliability of the results obtained.

In summary, the graphical analysis not only corroborates previous statistical findings but also provides a more intuitive and nuanced understanding of the complex interrelationships among dimensions of teachers' digital competence in the context of assessment and feedback.

The analysis of the scatter matrix for Dimension I (Facilitating Digital Competence) and its predictors reveals more complex and heterogeneous relationship patterns compared to Dimension G, which is consistent with the lower coefficient of determination (R^2 = .710) obtained in the statistical model.

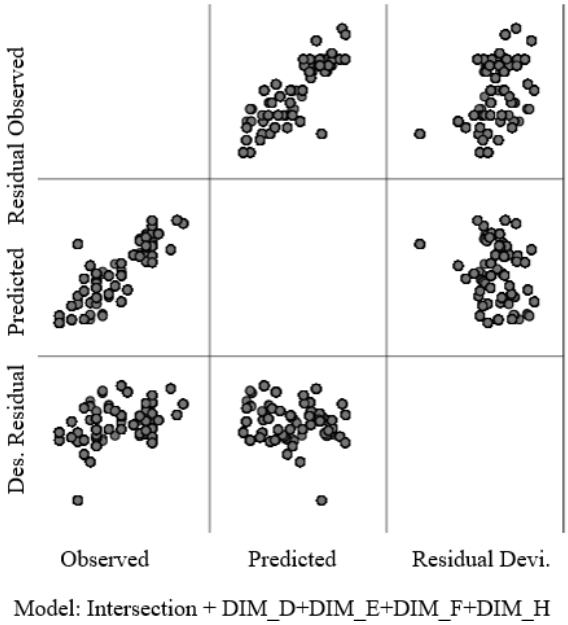
The most prominent feature is the dominant relationship between Dimension I and "Digital Pedagogy" (DIM_F). This association exhibits a strongly defined linear pattern with the least relative dispersion, visually corroborating the highest coefficient in the model (B = .883, η^2 partial = .291). The clarity of this relationship underscores the central role of digital pedagogical skills in facilitating digital competencies.

In contrast, the relationship between Dimension I and "Empowering Students" (DIM_H) displays a moderate positive association, characterized by a less pronounced linear pattern and greater dispersion. This visualization supports the moderately pos-

itive coefficient found (B = .214, η^2 partial = .030), suggesting a secondary yet significant influence of student empowerment on the facilitation of digital competencies.

Figure 2

Dependent Variable: Dimension I. Facilitating Digital Competence



The relationships of Dimension I with "Professional Engagement" (DIM_D) and "Digital Resources" (DIM_E) present more complex and diffuse patterns, with high dispersion. These visualizations are consistent with the negative coefficients obtained (B = - .111, η^2 partial = .007 for DIM_D; B = - .064, η^2 partial = .004 for DIM_E), indicating weak but statistically significant inverse relationships.

From a methodological perspective, linearity is more evident in the relationship with digital pedagogy, while relationships with other predictors show more complex patterns. This justifies the use of a linear model, primarily due to the strong association with DIM_F, but also suggests the possibility of exploring non-linear models to better capture these more complex relationships.

The greater heterogeneity in dispersion and more irregular patterns compared to Figure 1 (Dimension G) indicate increased complexity in relationships for Dimension I. This translates into a less balanced model, with a more pronounced dependence on digital pedagogy and more visible suppressor effects in other predictors.

In summary, the graphical analysis of Dimension I reveals a structure of relationships that is more complex and less homogeneous than that observed in Dimension G. This underscores the multifaceted nature of facilitating digital competencies and suggests the need for more nuanced approaches in training and evaluating this competence among educators.

Discussion and conclusions

This research has shed light on the complex interrelationship between teachers' digital competencies, digital assessment and feedback practices, and their impact on facilitating students' digital competencies in the context of higher education. The results obtained allow for significant conclusions to be drawn and open new lines of discussion regarding the digital transformation of education.

Firstly, concerning the first proposed objective, "to examine the multidimensional structure of teachers' digital competencies, with an emphasis on assessment, feedback, and facilitation of learning," the examination of this multidimensional structure has revealed the critical importance of digital pedagogy as a central axis of educational innovation. The findings suggest that the mere implementation of technological tools is insufficient; it is the transformation of pedagogical practices that truly drives the development of digital competencies in both teachers and students. The strong correlation observed between digital pedagogy and the dimensions of assessment and facilitation of competencies ($r = .863$ and $r = .835$, respectively) underscores the need to prioritize teachers' digital pedagogical training as a key strategy for educational transformation. Furthermore, the results demonstrate a clear interdependence between digital assessment and competency development, highlighting the centrality of digital pedagogy in educational transformation. These findings emphasize the necessity for an integrated approach in educational intervention that considers the interrelationship between these elements to achieve effective implementation of digital competencies in teaching.

In this regard, Falloon (2020) emphasizes the need to integrate digital competencies transversally into university curricula, arguing that such integration is fundamental for preparing students for the challenges of the contemporary digital world. This perspective aligns with the findings of Vuorikari et al. (2022), who established five main areas of digital competencies in the DigComp 2.2 framework: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. These areas provide a comprehensive structure for developing essential digital skills in higher education. Cabero-Almenara and Palacios-Rodríguez (2020) complement this vision by underscoring the importance of adapting these competencies to the specific needs of each discipline and professional profile. The effective implementation of this approach requires, according to Gómez-Trigueros et al. (2021), the adoption of innovative pedagogical strategies such as project-based learning and technology-mediated collaborative learning, which enable students to develop these competencies in authentic and meaningful contexts.

Regarding the second objective, "to analyse the interaction dynamics among dimensions of teachers' digital competence and their influence on promoting students' digital skills," multivariate analysis has revealed interesting patterns. The robust connection identified between digital assessment and facilitation of digital competencies ($r = .738$) suggests that strengthening digital assessment practices not only improves evaluative processes per se but also catalyses the development of digital skills in students. This finding supports the implementation of differentiated yet complementary formative assessment and self-assessment strategies mediated by technology, aligning with contemporary student-centred learning theories.

A particularly relevant finding is the role of student empowerment as a catalyst in digital assessment ($\eta^2 = .317$). This result suggests that evaluative practices that foster student autonomy and active participation are especially effective in digital environ-

ments. Such observations have significant implications for designing assessment and feedback strategies that promote the development of digital competencies more effectively by utilizing different mechanisms of influence for each dimension. Therefore, other authors such as Gómez-Trigueros et al. (2021) propose innovative pedagogical strategies like project-based learning and technology-mediated collaborative learning to develop digital competencies. These methodologies encourage an active and participatory approach, allowing students to apply their digital skills in authentic and meaningful contexts. Additionally, Pérez-Escoda and García-Ruiz (2021) complement this view by highlighting the importance of flipped learning in promoting students' digital skills. This pedagogical approach enables students to engage with digital content outside the classroom and participate in application and analysis activities during class time, thereby fostering autonomy in learning and providing more opportunities to develop and practice digital skills in a teacher-guided environment.

Finally, addressing the third objective, "to elucidate the interrelationship between teachers' digital competencies in assessment and feedback, and their influence on facilitating students' development of digital competencies," interesting patterns have emerged. The results indicate that teachers' ability to implement innovative digital assessment practices is closely linked to their ability to facilitate the development of digital competencies in their students. The findings indicate that teachers with advanced skills in digital assessment are more effective at promoting their students' development of digital competencies. Visual data analysis shows greater consistency in digital assessment practices and a clear dominance of digital pedagogy in competency development; however, significant complexity is also observed in integrating digital resources. These observations have important implications for teacher training and educational policies. They visualize the complexity of developing digital competencies, identify key intervention points for improving pedagogical practices, and provide evidence of implementation patterns that can guide future strategies in digital education.

These findings underscore the need for an integrated approach to teacher training that simultaneously addresses competencies in digital assessment and facilitates students' development of skills. Following this line, other authors such as Cabero-Almenara et al. (2021) emphasize the necessity for solid instructional design that aligns learning objectives, activities, and assessment in digital environments. This alignment is essential to ensure that digital technologies are effectively integrated into the educational process, maximizing their potential to develop students' digital competencies.

Tondeur et al. (2020) highlight the critical importance of teacher training in the pedagogical use of digital resources, arguing that mere availability of technology does not guarantee its effective use in classrooms to facilitate students' development of digital competencies. These authors stress that training should focus not only on technical skills but also on pedagogical strategies that allow for meaningful integration of technology into teaching, thereby ensuring educators are equipped to make full use of available digital tools.

It is important to note that this research has also identified areas for improvement and ongoing challenges. The moderate average scores on dimensions related to assessment and facilitation of competencies (M=2.89 and M=2.82, respectively) indicate that there is still significant room for developing and implementing advanced digital practices in higher education. The variability observed, particularly in competency facilitation (SD=1.09), reflects heterogeneity in adopting digital strategies among university faculty members, underscoring the need for more robust and personalized teacher training programs (Mohamed et al., 2022). This study highlights that institutions must

adopt a proactive approach toward digitization by integrating emerging technologies such as artificial intelligence and data analytics to enhance educational experiences.

In conclusion, this research provides solid empirical evidence supporting the need for a holistic approach to the digital transformation of higher education. The close relationship between digital assessment, digital pedagogy, and competency development suggests a need for educational policies and pedagogical practices that recognize and leverage these interconnections. The findings contribute not only to theoretical knowledge in the field but also offer practical guidelines for educational innovation in the digital age (Carayannis & Morawska-Jancelewicz, 2024). This work emphasizes that universities must be flexible and adaptive to face current educational environment challenges while promoting more personalized student-centred learning.

Future research could delve deeper into analysing long-term effects of these interrelationships as well as exploring how these dynamics vary across different academic disciplines. Additionally, it would be valuable to further investigate specific mechanisms through which student empowerment influences the development of digital competencies to design more effective educational interventions (UNESCO et al., 2024). This approach will enable a better understanding of how institutions can adapt their digital strategies not only to enhance learning but also to improve student retention and satisfaction in an increasingly digitized world.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Referencias

Boud, D., & Dawson, P. (2021). What feedback literate teachers do: an empirically-derived competency framework. *Assessment & Evaluation in Higher Education*, *46*(8), 1073-1085. https://doi.org/10.1080/02602938.2020.1860192

Cabero-Almenara, J., & Palacios-Rodríguez, A. (2020). Marco Europeo de Competencia Digital Docente «DigCompEdu». Traducción y adaptación del cuestionario «DigCompEdu Check-In». *EDMETIC, 9*(1), 213-234. https://doi.org/10.21071/edmetic.v9i1.12462

Cabero-Almenara, J., Barroso-Osuna, J., Palacios-Rodríguez, A., & Llorente-Cejudo, C. (2021). Digital Competency for Teachers: Perspective from a University Model. *Sustainability, 13*(23), 13283. https://doi.org/10.3390/su132313283

Cabero-Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A. (2021). Evaluación de los marcos de competencia digital docente mediante juicio experto: el uso del

coeficiente de competencia experto. *Journal of New Approaches in Educational Research, 10*(1), 80-98. https://doi.org/10.7821/naer.2021.1.623

Carayannis, E. G., & Morawska-Jancelewicz, J. (2024). Transformación digital en las Instituciones de Educación Superior. *Revista Latinoamericana de Tecnología Educativa, 22*(1), 42-56. https://doi.org/10.1016/j.jlss.2024.100456

Carless, D., & Boud, D. (2018). The development of student feedback literacy: enabling uptake of feedback. *Assessment & Evaluation in Higher Education, 43*(8), 1315-1325. https://doi.org/10.1080/02602938.2018.1463354

Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education, 15*(1), 22. https://doi.org/10.1186/s41239-018-0109-y

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*(5), 2449-2472. https://doi.org/10.1007/s11423-020-09767-4

García-Peñalvo, F. J., Corell, A., Abella-García, V., & Grande-de-Prado, M. (2021). Recommendations for Mandatory Online Assessment in Higher Education During the COVID-19 Pandemic. In D. Burgos, A. Tlili, & A. Tabacco (Eds.), *Radical Solutions for Education in a Crisis Context* (pp. 85-98). Springer Singapore. https://doi.org/10.1007/978-981-15-7869-4_6

Gašević, D., Kovanović, V., & Joksimović, S. (2019). Learning analytics in higher education: Challenges and policies. In C. Vieira, C. Parsons, & J. Byrd (Eds.), *Visual Data and Learning Analytics* (pp. 23-38). Springer. https://doi.org/10.1007/978-3-030-29374-1_3

Gikandi, J. W., & Morrow, D. (2019). Designing and implementing peer formative feedback within online learning environments. *Technology, Pedagogy and Education, 28*(5), 613-629. https://doi.org/10.1080/1475939X.2019.1688503

Gómez-Trigueros, I. M., Ruiz-Bañuls, M., & Ortega-Sánchez, D. (2021). Digital Literacy of Teachers in Training: Moving from ICTs (Information and Communication Technologies) to LKTs (Learning and Knowledge Technologies). *Education Sciences, 11(*4), 151. https://doi.org/10.3390/educsci11040151

Marín, V. I., Carpenter, J. P., & Tur, G. (2020). Pre-service teachers' perceptions of social media data privacy policies. *British Journal of Educational Technology, 52*(2), 519-535. https://doi.org/10.1111/bjet.13035

Martínez-Solana, M. Y., Sánchez-Esparza, M., & Rodríguez-Fidalgo, M. I. (2020). The role of data journalism in the integration of Big Data into the university curriculum. A case study of Spanish journalism faculties. *Revista Latina de Comunicación Social, 75*, 139-167. https://doi.org/10.4185/RLCS-2020-1420

Mercader, C., & Gairín, J. (2020). University teachers' perception of barriers to the use of digital technologies: the importance of the academic discipline. *International Journal of Educational Technology in Higher Education, 17*(1), 4. https://doi.org/10.1186/s41239-020-0182-x

Mohamed, A., Smith, J., & Johnson, R. (2022). Digital transformation in higher education: Challenges and opportunities. *International Journal of Educational Technology, 15*(3), 123-134. https://doi.org/10.1016/j.jhe.2022.100123

Pérez-Escoda, A., & García-Ruiz, R. (2021). Digital Skills Assessment in Higher Education: The DigiCom-College Questionnaire. *Education Sciences, 11*(12), 828. https://doi.org/10.3390/educsci11120828

Redecker, C. (2019). European Framework for the Digital Competence of Educators: DigCompEdu. *Publications Office of the European Union*. https://doi.org/10.2760/159770

Redecker, C., & Punie, Y. (2019). Digital Competence of Educators DigCompEdu. *Publications Office of the European Union*. https://doi.org/10.2760/159770

Rodríguez-García, A. M., Raso Sánchez, F., & Ruiz-Palmero, J. (2019). Competencia digital, educación superior y formación del profesorado: un estudio de meta-análisis en la Web of Science. Pixel-Bit. *Revista de Medios y Educación, 54,* 65-82. https://doi.org/10.12795/pixelbit.2019.i54.04

Sánchez-Cruzado, C., Santiago Campión, R., & Sánchez-Compaña, M. T. (2021). Teacher Digital Literacy: The Indisputable Challenge after COVID-19. *Sustainability, 13*(4), 1858. https://doi.org/10.3390/su13041858

Timmis, S., Broadfoot, P., Sutherland, R., & Oldfield, A. (2022). Rethinking assessment in a digital age: opportunities, challenges and risks. *British Educational Research Journal, 48*(3), 582-604. https://doi.org/10.1002/berj.3770

Tondeur, J., Scherer, R., Baran, E., Siddiq, F., Valtonen, T., & Sointu, E. (2020). Teacher educators as gatekeepers: Preparing the next generation of teachers for technology integration in education. *British Journal of Educational Technology, 50*(3), 1189-1209. https://doi.org/10.1111/bjet.12748

Tsai, Y. S., Poquet, O., Gašević, D., Dawson, S., & Pardo, A. (2020). Complexity leadership in learning analytics: Drivers, challenges and opportunities. *British Journal of Educational Technology, 51*(6), 2304-2320. https://doi.org/10.1111/bjet.12846

UNESCO, UNICEF, UIT, & GPE. (2024). *Lanzamiento de un modelo conjunto para guiar la transformación digital de la educación.* UNESCO. https://doi.org/10.1007/s11159-024-09765-3

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes. *Publications Office of the European Union*. https://doi.org/10.2760/115376

Williamson, B., Bayne, S., & Shay, S. (2020). The datafication of teaching in Higher Education: critical issues and perspectives. *Teaching in Higher Education, 25*(4), 351-365. https://doi.org/10.1080/13562517.2020.1748811