Evaluation of a Program to Enhance Online Lecturers' Digital Competence: TPACK and Artificial Intelligence

Carmen Romero García
Universidad Internacional de La Rioja

Olga Buzón-García
Universidad de Sevilla

Elena Parra González
Universidad de Granada

Abstract
The integration of technology in educational contexts has become a reality that must be addressed in both initial and ongoing teacher training. Lecturers require knowledge to incorporate digital tools into their pedagogical practices and to support constructivist learning (Ortiz et al., 2025). We have designed a training program, based on the Technological Pedagogical Content Knowledge (TPACK) model approach and the digital competence framework for teachers proposed by the Instituto Nacional de Tecnologías Educativas y Formación del Profesorado (INTEF). This program combines the use of various digital tools, including generative AI, within an instructional design aimed at implementing an active and participatory learning model in a virtual environment. A quantitative methodology was employed with a pre-experimental, pre-test and post-test research design. The sample consisted of 78 lecturers teaching at the Universidad Internacional de La Rioja (La Rioja International University), an online university, across different fields of knowledge. An ad hoc instrument was used to collect data on lecturers' perceptions of their digital competence before and after the training program. It comprised two dimensions: pedagogical knowledge and pedagogical technological knowledge, with subdimensions linked to instructional design events. Statistically significant differences were found in all items of the two dimensions used to measure digital competence based on the TPACK model and areas 2, 3 and 4 of the INTEF. We concluded that the training program was effective and had a notable impact on improving the digital competence of lecturers, who expressed high satisfaction with the program.

Keywords: Digital competence; Pedagogy; Technology; Artificial intelligence; Online teacher training; Higher education.

Romero-García, C., Buzón-García, O. & Parra González, E. (2025). Evaluation of a Program to Enhance online Lecturers' Digital Competence: TPACK and Artificial Intelligence, *Online Learning*, *29*(4), 109-132. https://doi.org/10.24059/olj.v29i4.5016

Introduction

The integration of digital technologies into education has rapidly evolved in recent decades. In the educational context, its introduction is viewed from a dual perspective: the actual learning of it to foster students' digital literacy and as a means to other kinds of learning (Cabero-Almenara et al., 2020). At present, quality education requires the inclusion of Information and Communications Technology (ICT) in the classroom, and this is only possible if lecturers have an adequate level of digital competence. In fact, this competence, particularly since 2020, has been acknowledged to be a key skill for teaching performance at all educational levels (Dervenis et al., 2022) and as an indicator of educational system quality (Martín Párraga et al., 2022; Mas García et al., 2023). The digital skills of contemporary educators are of vital importance in the teaching of different areas and subjects, as they affect the improvement of the teaching/learning process, as well as that of student and teacher assessment, and they help teaching staff to collaborate with each other and stay up to date (Carpenter et al., 2024). However, the use of technology does not ensure, in itself, greater student learning, as digital technologies need to be integrated into all the pedagogical aspects of education (Cejas-León & Navío, 2018).

Different studies have evidenced university lecturers' lack of preparation in the pedagogical integration of technology (Busbar Sánchez et al., 2022; García-Peñalvo, 2023; Pizà-Mir et al., 2023), often linking their skills to purely instrumental use (Marín Suelves et al., 2022; Melash et al., 2020; Muñoz and Ruiz-Domínguez, 2021). Furthermore, these studies emphasize that the most influential factors in developing lecturers' digital competence are initial and ongoing teacher training that incorporates models of pedagogical technology integration in the classroom (García-Ruiz et al., 2023; Jiménez-Hernández et al., 2021; Maiier & Koval, 2021), as well as the promotion of a positive (Cattaneo et al., 2022; Hämäläinen et al., 2021) and responsible attitude towards technology use among educators (Baena-Morales et al., 2020; García-Ruiz & Pérez-Escoda, 2020).

Among the various digital competence frameworks proposed by organizations and researchers for teacher training and evaluation, two have emerged as key benchmarks: the European Framework for the Digital Competence of Educators (DigCompEdu) (Redecker & Punie, 2017) and the Marco de Referencia de la Competencia Digital Docente, a Spanish Framework for the Digital Competence of Teachers, developed by INTEF (Banoy-Suarez & González-Reyes, 2024; Cabero et al., 2021; García-Ruiz et al., 2023; Palacios et al., 2024).

The INTEF framework is an adaptation of DigCompEdu for the Spanish education system and includes a particularly noteworthy feature: it embeds digital competence within a student-centered teaching model that promotes both independent and collaborative learning for progressive skills development.

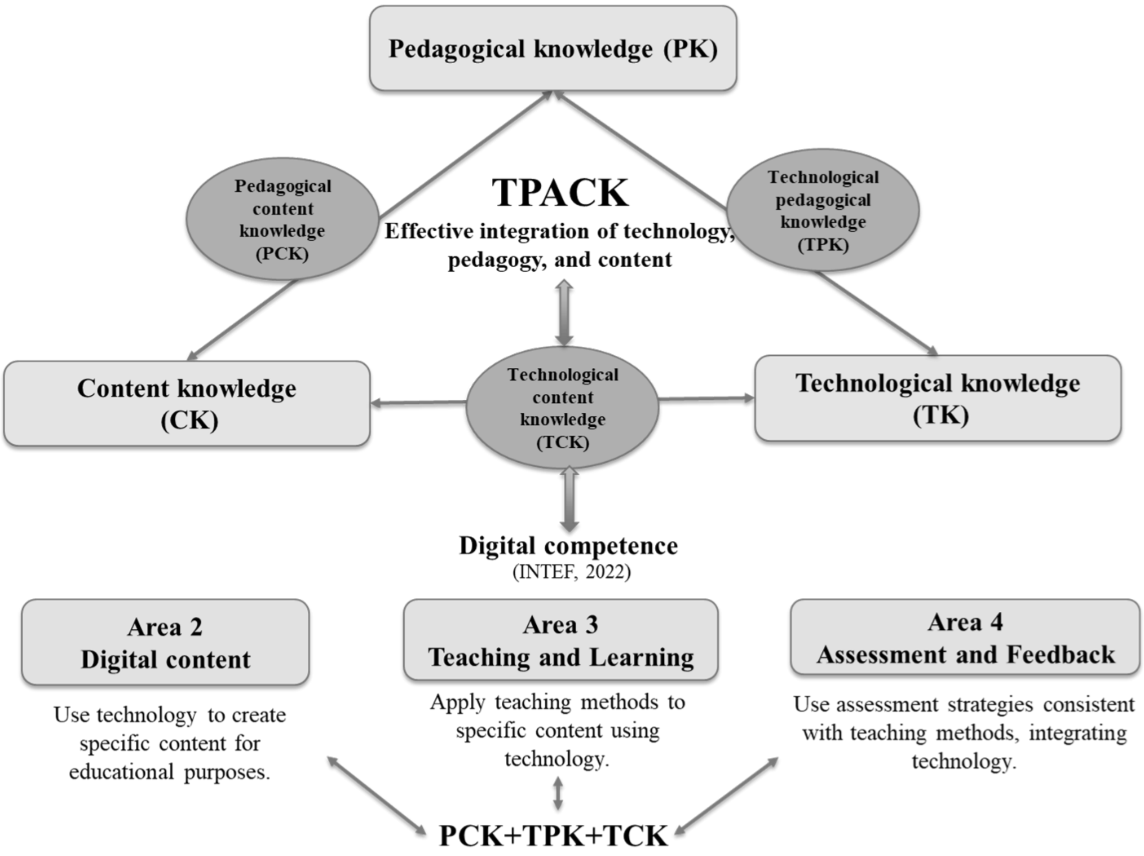
Literature Review

This study adopts the INTEF framework for designing the training program implemented. It operates on the premise that instructing teachers solely in the technical use of digital tools is insufficient. Instead, meaningful development and assessment of digital competence must be rooted in collaborative practices that integrate both technology and pedagogy. It organizes lecturers' digital competences into six areas, grouped into three overarching blocks: (1) professional competences, (2) pedagogical competences, and (3) pedagogical competences aimed at developing students' digital competence. The core of the framework lies in areas 2 through 5, which form the second block—teachers' pedagogical competences—and focus specifically on digital skills related to teaching and learning processes. Area 2– Digital content, refers to searching for, modifying and creating digital content; area 3– Teaching and learning, refers to the use of digital technologies in teaching and learning; area 4– Assessment and feedback, refers to the use of technology to improve the assessment of students and the overall teaching–learning process; and area 5– Empowering learners, addresses the use of technology to cater to individual student needs and differences.

To analyze the competences that each of these areas should include, as a reference this framework for the digital competence of teachers (INTEF, 2022) uses the theoretical model suggested by Mishra and Koehler (2006), called the TPACK model or the Technological Pedagogical Content Knowledge model (TPACK). It is based on the necessary integration and interaction of three types of knowledge: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), for teachers to acquire digital competence. These types of knowledge hybridize and generate new knowledge. Thus, the combination of CK and PK generates Pedagogical Content Knowledge (PCK), which enables teachers to select appropriate instructional methods for teaching a specific subject. The combination of PK and TK gives rise to Technological Pedagogical Knowledge (TPK), which explains how technologies can modify, enrich, or transform teaching strategies and classroom dynamics. In turn, the integration of CK and TK produces Technological Content Knowledge (TCK), which shows how technologies make it possible to represent, explore, or reorganize disciplinary content in new ways. Finally, the confluence of these three types of knowledge creates an interaction between technology, disciplinary content, and pedagogy, which is defined as technological pedagogical content knowledge (TPACK) (Koehler & Mishra, 2009). The INTEF Areas 2, 3, and 4 can be interpreted through their connection with the TPACK model, showing that digital teaching competence is not limited to technological knowledge but emerges from the meaningful integration of technology, pedagogy, and content. Area 2, Digital Content, is related to technological knowledge and its hybridization with content (TCK), as it involves using technology to design, adapt, and select educational materials. Area 3, Teaching and Learning, is linked to pedagogical knowledge and its combination with technology (TPK), highlighting how digital tools transform activity design, classroom organization, and learner participation. Area 4, Assessment and Feedback, is associated with content knowledge and its interaction with technological knowledge (TCK), as it involves using digital tools to assess content-related learning and to provide meaningful, evidence-based feedback. In this way, INTEF Areas 2, 3 and 4 are connected to the TPACK model, as they can be understood as the result.

Figure 1

Relationship between the TPACK model and digital competence (INTEF, 2022)



Note. Own elaboration based on INTEF, 2022 and Mishra and Koehler, 2006.

This model has become a reference framework for teacher training by effectively integrating technology into the teaching/learning process and the development of digital competences (Cabero & Barroso, 2016; Demeshkant et al., 2022) It is applicable across various subject areas (Binjha et al., 2023; Valtonen et al., 2017) and in both in-person and online learning environments (Valverde & Balladares, 2017). It focuses techno-pedagogical teacher training on skills development to include the ideal digital tools for specific disciplinary content, through constructivist pedagogical methods that improve student learning (Koehler et al., 2015).

In recent decades there have been numerous studies on this model, many of them as a result of the COVID-19 pandemic. Teachers were forced to be innovative in their teaching practices and incorporate technological tools (Balladares, 2020). The aforementioned model has evolved to adapt to the needs of modern society in terms of educational digital competences. This is how the model called TPACK-21 CL arose, which incorporates the digital competences needed by twenty-first century teachers (Koh et al., 2017) and highlights the importance of having a solid pedagogical basis for the integration of technology in order to achieve active, experiential student learning where technology is also involved. It advocates training teachers in digital competence through an educational process based on designing a didactic unit that provides meaningful learning experiences (Balladares, 2018). In turn, the study by Harris and Hofer (2017) defines different profiles for the TPACK model that can be used in teacher training, such as the focus on flexible tools. When this profile is employed for designing training programs, digital tools are selected that can be used in different areas of knowledge and teachers receive guidance on the various possibilities for using these tools. The training program presented in this paper is based on the TPACK-21 CL model and aims to design a didactic proposal drawn from the participating teachers, selecting a series of tools with flexible uses.

Implementing a teacher training program based on the TPACK model helps to improve educational quality in different learning environments. Cadena (2022) established a strong positive correlation between the use of the TPACK model and an improvement in the teaching/learning process. The studies by León Naranjo (2024) emphasized that ongoing teacher training in the use of ICT using the TPACK model aided the effective integration of various digital resources into real teaching and learning practices. The studies by González-Pérez and Marrero-Galván (2023) and Miguel-Revilla et al. (2020), conducted with future teachers, evidenced the importance of improving their training in the integration of technology in teaching/learning processes in line with the TPACK model.

At present, the TPACK model is a benchmark in developing digital competence and instructional design in virtual learning environments (Vowell, 2024; Balladares-Burgos & Valverde-Berrocoso, 2022). In such environments, the use of technology provides wider opportunities to implement constructivist models focusing on active, experiential student learning. There are currently a vast number of digital tools that can be included at different points of instructional design, thereby facilitating content presentation, collaboration, activity design, and assessment. Most recently, Generative Artificial Intelligence (GenAI) tools, which spread as a result of the launch of ChatGPT in 2022, have boosted the number of digital tools that teachers can use to streamline their teaching work. Introducing GenAI into the teaching/learning process presents a great pedagogical potential. Due to their flexibility, GenAI tools enable teachers to create and update content, identify prior ideas, create personalized learning experiences, prepare questionnaires and assessment rubrics, and obtain feedback on completed tasks (Sullivan et al., 2023; Vidal et al., 2024). In short, GenAI has great potential to support instructional design (Kumar et al., 2024). Nevertheless, there are concerns related to the use of GenAI, such as the matter of plagiarism and the production of contents that lack originality (Ellis & Slade, 2023), with the subsequent need to create alternative assessment methods and the possibility of creating bias in the results offered by these tools (Wach et al., 2023). For this reason, although it is important to take steps to integrate GenAI responsibly and reliably, effective integration of GenAI tools should also be based on the teaching/learning process (Gallent-Torres et al., 2023). According to Ayuso-del Puerto and Gutiérrez-Esteban (2022), the use of GenAI tools should now be part of the training programs aimed at improving teachers' digital competence. The qualification of teachers in pedagogical and digital competences is a present-day challenge that involves using GenAI tools (Alenezi et al., 2023).

On the basis of the aforementioned arguments, there is a clear need to design training programs that contemplate the interaction between technological and pedagogical knowledge regarding content, to train teachers in digital competence (Vowell, 2024). Additionally, it is vitally important that these proposals include the areas that the framework for the digital competence recommended by INTEF (2022) considers to be most significant for teachers' pedagogical competences (Miguel-Revilla et al., 2020). On the other hand, it is currently essential to incorporate GenAI tools as part of digital competence training programmes (Cacho, 2024).

In this regard, the following research questions are posed:

- To what extent does a training program based on the TPACK model improve the digital competence of university teachers in areas 2, 3 and 4 according to the INTEF framework?
- Which dimensions of the TPACK model and which phases of instructional design are most strengthened after the training intervention?
- Which elements of the training program have contributed most to the improvement in competence?

Therefore, the main objective of this research is to analyze the effectiveness of a training program grounded in the TPACK model, designed to support the integration of various digital tools—including AI-based tools—across different stages of instructional design, with the aim of enhancing the digital competence of university lecturers at a fully online institution. Furthermore, this proposal also considers digital competence areas 2, 3 and 4 as outlined by INTEF (2022).

Methodology

In this study, a quantitative methodology was employed using a pre-experimental research design, with pre-test and post-test measures aimed at evaluating the improvement in lecturers' digital competence following the completion of a training programme. Specifically, a questionnaire was administered to the lecturers prior to the start of the course (pre-test), and the same questionnaire was administered again at the end of the course (post-test). The pre-test served to establish a baseline measure of the participants' digital competence, while the post-test enabled an assessment of the progress made as a result of the training intervention.

Participants

A non-probability convenience sample was used, as the experiment was conducted on a professional development course taught by the researchers. The universe was composed of 100 lecturers. The sample consisted of 78 lecturers teaching at the Universidad Internacional de La Rioja (UNIR), from different fields of knowledge, who attended the training course 'Metodologías Activas y herramientas digitales en el proceso de aprendizaje en la enseñanza universitaria online' [Active methodologies and digital tools in the learning process in online university education] during the 2023/24 academic year. This course is part of the 'Título de Experto Universitario en aprendizaje y enseñanza universitaria online' [University Expert Degree in online university teaching and learning]. Women represented 73.1% and 26.9% were men, with an average age of 49.15 years. In terms of years of teaching experience prior to the online environment, 11.5% had less than a year's experience, 38.5% had between 1 and 3 years, 26.9% had between 4 and 10 years and 23.1% had over 10 years of experience.

Procedure

We designed a training program consisting of eight weekly sessions, each lasting three hours and delivered synchronously via the Adobe Connect platform. The program aimed to equip university lecturers with the skills to implement an active and participatory teaching and learning model in virtual classrooms by allowing them to experience this model firsthand. The session design incorporated the moments or events suggested by Gagné and

Dick (1983) in the instructional design. Each event was developed through activities that used different digital tools, some of them were GenAI and others, albeit not GenAI, involved new GenAI functions. During the sessions, tool usage was explained, and supplementary video tutorials were made available to participants. Lecturers selected a topic from one of the subjects they taught and used their corresponding PowerPoint presentation to apply all assigned tasks to specific contents. The input generated by the individual activities was shared on the Moodle platform and the group activities were presented in the classroom and shared on Wakelet ensuring all participants had access to the shared materials. Formative assessment was conducted by providing feedback to the teaching staff both during the completion of the activities on the virtual platform and on the final product they developed. In order to evaluate both the process and the final outcome, a rubric was used as the assessment tool. This rubric was shared with the teaching staff at the time the activity was introduced, thus ensuring that they were aware of the assessment criteria from the outset.

The training programme was framed within a gamification-based methodology. A narrative was designed and presented to the participating lecturers during the first session through an introductory video. Throughout the course, a series of challenges or learning activities were proposed, all contextualized within this narrative. Each time a challenge was completed, participants received a badge containing a number. Once all the badges had been collected, they obtained a code that allowed them to unlock a padlock and gain access to a privilege that supported their successful completion of the course.

Table 1 shows the instructional design events, activities, or challenges and digital and GenAI tools used in each session on the training program. The following link provides a detailed description of the instructional design: Metodología docente y estrategias discursivas en las sesiones virtuales.

Table 1

Instructional Design Events, Activities and Digital and GenAI Tools

Instructional design	Activities or Challenges, and digital and GenAI tools
Event: To attract the students' attention (Session 1)	Presentation of the trainer and the participants (https://padlet.com/)
	Identification of prior ideas (https://app.wooclap.com/). Presentation of the learning model to use and the instructional design events.
	Creation of a collaborative mural (https://linoit.com/) for the lecturers to express how they implemented these events in the virtual classroom.
Event: To inform about objectives, Objective design (Session 2)	Identification of prior ideas about what a learning objective is and about Bloom's taxonomy (https://www.perplexity.ai/). Explanation of what a prompt is and how to create one. Presentation of prior ideas (https://www.mentimeter.com/).
	Explanation of how to design objectives using Bloom's taxonomy. The lecturers designed the learning objectives using Bloom's taxonomy for the selected topic. This was shared (https://docs.google.com/) and feedback was provided.

Instructional design	Activities or Challenges, and digital and GenAI tools
Events: Prior ideas, Content presentation (Sessions 3 and 4)	Review of content from Session 2 (https://jamboard.google.com/). Explanation of how to identify students' prior ideas and present content at the same time. Completion of three individual activities. • Activity 1: creation of an interactive presentation to synchronously present the contents using the PowerPoint for the selected topic (https://app.wooclap.com/). • Activity 2: creation of a video based on the abridged PowerPoint (6-7 slides) (https://zoom.us/), which was enhanced with questions (https://edpuzzle.com/). The GenAI on Edpuzzle was used to suggest questions and insert them automatically into the video. The enhanced video makes it possible to present content asynchronously and review the answers before the class. • Activity 3: creation of a course (https://app.perusall.com/) and a task so that students read a document that complements the content presented in the video. Using the GenAI on *Perusall,* possible questions were obtained to guide the reading of the document.
Events: To put learning into practice, To provide feedback to guide learning (Sessions 5 and 6)	Review of content from Sessions 3 and 4 (https://quizizz.com/). An explanation was provided on how to use this tool and the possibility of using the GenAI involved to generate questions. The lecturers conducted guided reading, by means of a series of questions, of a document uploaded to *Perusall*, on 'Metodologías activas y tipos de actividades' [Active methodologies and types of activities]. This was discussed in Session 5. Based on the document, a co-operative conceptual map was created (groups of 6) (https://www.mindmeister.com/ or https://www.canva.com/). There was an opportunity to use the tool https://www.chatpdf.com/ to summarize the document. The maps were shared on https://wakelet.com/. Presentation and evaluation of the maps (self-evaluation, peer evaluation, and hetero-evaluation). Collaborative activity (groups of six, in areas of knowledge) to design an activity as part of an active methodology and supported by an ICT and/or GenAI tool. It was possible to use the tool https://chatgpt.com/ to generate ideas. The activity was shared on https://wakelet.com/.
Event: Evaluation of learning (Sessions 7 and 8)	Review of content from Sessions 5 and 6 (game with cards https://wordwall.net). Identification of prior ideas (roulette game https://wheelofnames.com/). Explanation of types of evaluation, procedures, and instruments.

Instructional design	Activities or Challenges, and digital and GenAI tools
	Preparation of a rubric to evaluate the collaborative activity designed in session 6 using https://chatgpt.com/ or http://rubistar.4teachers.org/index.php Presentation of the activity conducted and evaluation (self-evaluation, peer evaluation and hetero-evaluation) using *Corubric*.
Final challenge	Final review of the course contents (https://b.socrative.com/). An explanation was given about how to create questionnaires with this tool, as well as the option of generating questions with GenAI. The lecturers that completed all the challenges received a password that unlocked a virtual padlock. They then entered a virtual classroom created with the augmented reality tool (https://www.spatial.io/) and searched for the padlock. When they introduced the password, a message appeared telling them that they had completed the end-of-course task.

Instrument

An ad hoc questionnaire was designed to gather information on lecturers' perceptions of their digital competence. It comprised two dimensions: ‘pedagogical knowledge’ and ‘pedagogical technological knowledge’. The first dimension established two subdimensions: ‘instructional design’ with 13 items, which reported the lecturers’ level of skill in carrying out a series of tasks relating to instructional design, and ‘use of active methodologies’ with six items, which addressed the use of the main active methodologies. The second dimension was composed of 20 items relating to knowledge of digital tools and GenAI, and 20 items about their use, divided into four subdimensions: ‘identification of prior ideas’, ‘content presentation’, ‘activity design’ and ‘evaluation’. Content knowledge is integrated into both dimensions. This is because participating lecturers directly translate their learning into the design of an instructional session for the subject they teach and subsequently implement it in the virtual classroom. The post-test included a third dimension referring to the lecturers’ satisfaction with the training received. This was composed of 13 items that evaluated to what extent the organizational elements of the course had an impact on improving their competence, to what extent the ICT and GenAI tools facilitated instructional design in the virtual classroom, the usefulness of the course for teaching practice, and their overall satisfaction. The items were answered on a Likert scale (1-Not at all, 2-A little, 3-Somewhat, 4-Quite a lot, 5-Very much so). The reliability of the instrument was determined by Cronbach’s alpha, and this was 0.959. The instrument was considered suitable for the research to be conducted.

Procedure for data collection and analysis

The questionnaire was shared with the lecturers online. All the participants, after being informed of the research objectives and that the confidentiality of their data was guaranteed, agreed to participate in this study. The instrument and research were approved by the UNIR Ethics Committee (PI: 098/2023). The statistical tests used were chosen based on the prior assumption of normality check. We used the Kolmogorov -Smirnov and Shapiro-Wilk tests. The results displayed significant values ($p < 0.05$) for all the items and dimensions, so therefore the data did not fit a normal distribution, and non-parametric statistics were used. Specifically, we used the Wilcoxon signed-rank test to determine whether there were differences in the level of digital competence before (pre-test) and after the intervention (post-test). To determine the magnitude of significant differences, Cohen's d was used to calculate the effect size. Small effects were considered to be r values of between 0.1 and 0.3, medium effects up to 0.5 and large effects above this value (Fritz et al., 2012). The data were organized, coded, and analyzed using the statistical software SPSS V.29.0.

Results

In relation to the first dimension, 'pedagogical knowledge' (PK), the overall results showed statistically significant differences with a large effect size (z=6.201, p=.001, r=0.70). Furthermore, the results of the Wilcoxon W test (Table 2) indicated statistically significant values ($p < 0.05$) in the two subdimensions that comprise this dimension. The effect size was large in both the subdimension 'instructional design' (r=0.68) and the subdimension 'use of active methodologies' (r=0.61).

Table 2

Results of the Wilcoxon W Test for the Subdimensions of Pedagogical Knowledge

Dimensions	Subdimensions	Ranges	n	Sum of ranges	Z	*p*	r
Pedagogical Knowledge (PK)	Instructional design	Positive	57	2206.50	-5.977	.001	0.68
		Negative	12	208.50			
		Ties	9				
	Use of active methodologies	Positive	54	1944.00	-5.366	.001	0.61
		Negative	12	267.00			
		Ties	9				

By analyzing each item in the subdimension 'instructional design' (Table 3) we found that statistically significant differences with large effect sizes were obtained for all the items, except item Di7, whose effect was medium and item Di13, whose effect size was small.

Table 3

Results of the Wilcoxon W Test for the Items in the Subdimension of Instructional Design

	Items on the subdimension of instructional design	Z	*p*	r
Di1	Designing learning objectives using Bloom's taxonomy	-5.837	.001	0.66
Di2	Requesting information about students' prior knowledge	-4.778	.001	0.54
Di3	Creating content in different formats (presentations, videos, and interactive documents)	-5.307	.001	0.60
Di4	Designing activities based on active methodologies adapted to the subject	-5.957	.001	0.67
Di5	Designing activities with digital tools	-5.190	.001	0.59
Di6	Organizing collaborative activities in the virtual classroom that arouse the students' interest	-6.157	.001	0.70
Di7	Giving indications to the student when presenting an activity (what to do, how to do it, and which space to use...)	-3.674	.001	0.42
Di8	Summarizing the work conducted in the classroom	-4.708	.001	0.53
Di9	Conducting a full student assessment (initial, procedural, final)	-5.307	.001	0.60
Di10	Integrating self-evaluation, peer evaluation and hetero-evaluation	-5.957	.001	0.67
Di11	Using a variety of instruments for evaluation	-5.190	.001	0.59
Di12	Providing feedback to guide students' learning	-4.730	.001	0.53
Di13	Maintaining a good atmosphere in the virtual classroom	-3.135	.002	0.35

As for the analysis of each item in the subdimension 'use of active methodologies' (Table 4) we found statistically significant differences with medium to large effect sizes for all the items.

Table 4

Results of the Wilcoxon W Test for the Items in the Subdimension Use of Active Methodologies

	Items in the subdimension use of active methodologies	Z	*p*	r
Ma1	Co-operative learning	-3.848	.001	0.44

Items in the subdimension use of active methodologies		Z	*p*	r
Ma2	Collaborative learning	-3.749	.001	0.42
Ma3	Problem-based learning	-3.763	.001	0.43
Ma4	Project-based learning	-3.920	.001	0.44
Ma5	Game-based learning	-3.996	.001	0.45
Ma6	Gamification	-3.568	.001	0.40

Regarding the second dimension under study relating to 'technological pedagogical knowledge' (TPK), the overall results show statistically significant differences, with a large effect size (z=-7.375, p=.001, r=0.83).

We analyzed the subdimensions that comprised TPK relating to knowledge of different digital tools. The results of the Wilcoxon W test indicated statistically significant values ($p < 0.05$) in the four subdimensions that comprise this dimension (Table 5) with large effect sizes in all of them.

Table 5

Results of the Wilcoxon W Test for the Subdimensions that Comprised TPK Competence Related to Knowledge of Different Digital Tools.

Subdimensions of the TPK competence	Ranges	n	Sum of ranges	Z	*p*	r
Prior ideas	Positive	78	3081	-7.681	.001	0.87
	Negative	0	.00			
	Ties	0				
Content presentation	Positive	72	2628	-7.382	.001	0.84
	Negative	0	.00			
	Ties	6				
Activity design	Positive	78	3081	-7.678	.001	0.87
	Negative	0	.00			
	Ties	0				
Evaluation	Positive	78	3081	-7.684	.001	0.87
	Negative	0	.00			
	Ties	0				

Once again, we analyzed the subdimensions that comprised TPK relating to use of different digital tools. The results of the Wilcoxon W test indicated statistically significant values ($p < 0.05$) in the four subdimensions that comprise this dimension (Table 6) with large effect sizes in all of them.

Table 6

Results of the Wilcoxon W Test for the Subdimensions that Comprised TPK Competence Related to the Use of Different Digital Tools.

Subdimensions of the TPK competence	Ranges	n	Sum of ranges	Z	*p*	r
Prior ideas	Positive	72	2628	-7.389	.001	0.84
	Negative	0	.00			
	Ties	6				
Content presentation	Positive	60	2329.50	-6.729	.001	0.76
	Negative	9	85.50			
	Ties	9				
Activities	Positive	69	2554.50	-6.968	.001	0.79
	Negative	3	73.50			
	Ties	6				
Evaluation	Positive	63	2155.50	-6.714	.001	0.76
	Negative	3	55.50			
	Ties	12				

Finally, we conducted an item-by-item analysis of each of the four subdimensions that comprise the TPK dimension relating to both knowledge and use of different digital tools at different points in the instructional design. The results obtained (Table 7) show statistically significant differences in all of the items in the subdimensions. As for the items in the subdimension of knowledge of digital tools, it is worth noting that all the effect sizes are large. Furthermore, regarding the items in the subdimension of use of digital tools, the effect sizes are large for all the items.

Table 7

Results of the Wilcoxon W Test for all items in the Subdimensions in the TPK Dimension

Items in each of the TPK subdimensions		Knowledge of digital tools			Use of digital tools		
		Z	*p*	r	Z	*p*	r
Prior ideas	Wooclap	-6.794	.001	0.77	-5.939	.001	0.67
	Linoit	-7.123	.001	0.81	-6.073	.001	0.69
	Padlet	-6.800	.001	0.77	-5.508	.001	0.62
	Perplexity	-7.472	.001	0.85	-6.451	.001	0.73
Content presentation	Zoom	-5.262	.001	0.60	-4.416	.001	0.50
	Edpuzzle	-7.118	.001	0.81	-5.839	.001	0.66
	Perusall	-7.140	.001	0.81	-5.709	.001	0.65
Activities	Mindmeister	-7.134	.001	0.81	-6.481	.001	0.73
	Wakelet	-6.958	.001	0.79	-4.745	.001	0.54
	Jamboard	-6.202	.001	0.70	-5.541	.001	0.63
	Collaborative docs	-6.507	.001	0.74	-6.787	.001	0.77
	ChatGPT	-6.803	.001	0.77	-5.619	.001	0.64
	Spatial IO	-6.571	.001	0.74	-5.908	.001	0.67
	ChatPDF	-6.590	.001	0.75	-5.747	.001	0.65
Evaluation	Mentimeter	-7.394	.001	0.84	-5.920	.001	0.67
	Quizziz	-7.120	.001	0.81	-6.186	.001	0.70
	Socrative	-6.987	.001	0.79	-6.136	.001	0.69
	Rubistar	-6.842	.001	0.77	-5.568	.001	0.63
	Corubrics	-7.321	.001	0.83	-5.739	.001	0.65

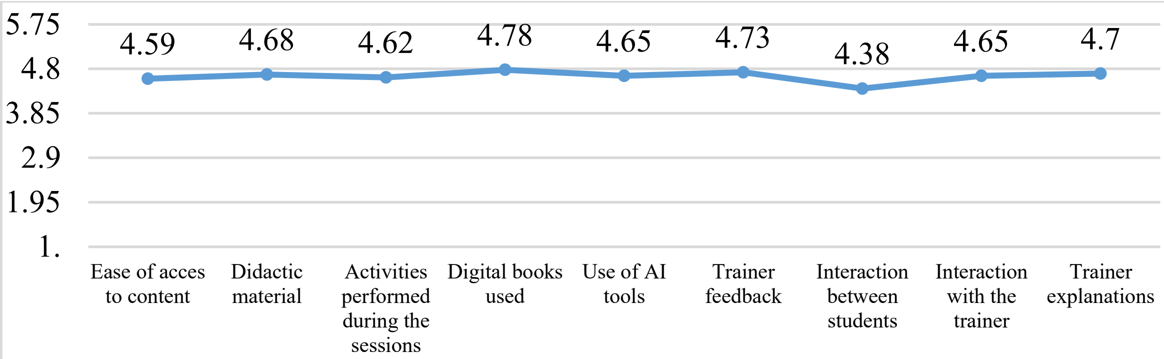
Regarding the degree of satisfaction with the training received, 100% of the lecturers indicated that the course had been useful for their teaching practice and they would recommend it to other lecturers, rating the experience overall with a score of 4.86 (on a scale from 1 to 5), therefore we can state that satisfaction was high.

In examining satisfaction further, we asked the lecturers to evaluate to what extent some organizational elements of the course had had an impact on improving their competence (Figure 2). To this effect, it can be seen that all of the items have a mean of over

4 (on a scale of 1 to 5), which means that all the elements used in the instructional design improved their digital competence. It should be noted that digital tools (4.78) trainer feedback (4.73) are two of the most highly rated elements.

Figure 2

Mean scores of the elements used in organizing the course



Lastly, we asked them to evaluate the extent to which digital tools and GenAI tools had made the instructional design easier, which resulted in an average of 4.75 and 4.43 respectively (on a scale of 1 to 5).

Discussion

This paper presents the results of implementing a training program based on the TPACK model approach (Koehler & Mishra, 2009), aimed at improving the digital competence of lecturers at a fully online university. This proposal is based on the integration of pedagogical and technological knowledge, applied to disciplinary content, that lecturers should have in order to implement a constructivist learning model in the virtual classroom (Koehler et al., 2015; Vowell, 2024). Additionally, it focuses on improving areas 2, 3 and 4 described in the Spanish Framework for the Digital Competence of Teachers (INTEF, 2022), related to the use of technology for digital content creation, teaching and learning activities, and evaluation, respectively. This framework for digital competence was suggested by García-Ruiz et al. (2023) as a benchmark to understand which digital competences teachers should develop.

The TPACK model and the reference framework for digital competence (INTEF, 2022) have been useful in designing the training program presented. The results obtained demonstrate the effectiveness of this proposal in improving lecturers' digital competence in a virtual environment (Banoy-Suarez & González-Reyes, 2024). This competence is crucial for ensuring quality in the teaching profession (Dervenis et al., 2022), and training in this area has increasingly focused on integrating technology into pedagogical practices, as highlighted by Maiier and Koval (2021). The intervention fostered a positive attitude among lecturers towards the use of technology in classroom practices and towards training in this area, as evidenced by the high level of satisfaction reported by lecturers with the training they received (Melash et al., 2020). The training programs and the attitude towards the use of technology were acknowledged as two of the key variables greatly influencing the level of lecturers' digital competence (Cattaneo et al., 2022; Hämäläinen et al., 2021). It is worth mentioning that this perception of improved digital competence was complemented by formative assessment of the lecturers throughout the program. All the input produced by the lecturers was evaluated through feedback based on the previously shared evaluation rubrics. In fact, the feedback provided by the trainer was the second most highly rated element of the course in terms of contributing to the improvement in the lecturers' competence. Authors such as Miguel-Revilla et al. (2020) and Viñoles-Cosentino et al. (2021) have considered formative assessment to be a decisive factor in the improvement of digital competence on training programs.

The development of digital competence has been examined in terms of knowledge and use of different digital tools, including GenAI, chosen for their potential in implementing an instructional design in the virtual classroom that incorporates the following events: prior ideas, content presentation, activity design, and evaluation.

The training program supported lecturers in developing their pedagogical content knowledge. To achieve this, they completed all tasks related to each instructional design event within the context of a topic from one of the subjects they teach. This is evidenced by the significant differences—with medium to large effect sizes—observed across all items related to the instructional design tasks. Additionally, lecturers showed notable improvement in their use of the active methodologies covered in the course and included in the instructional design, with statistically significant gains and medium effect sizes. All the above leads us to state that pedagogical knowledge has been created, applied to the contents that each lecturer must work on with their students. To this effect, and as proposed by the TPACK-21 CL (Balladares, 2018; Koh et al., 2017), this established the basis for integrating technology into pedagogy, though aimed at producing meaningful learning among students.

Furthermore, on this program technological knowledge interacted with pedagogical knowledge, since the most suitable digital tools were selected to facilitate the tasks to complete for each instructional design event. Upon completing the program, lecturers demonstrated the ability to understand and effectively use all the digital tools, as evidenced by significant improvements across all related items, each showing large effect sizes. Among these tools, some were GenAI, and others contained GenAI functions, as explained in the section on procedure. The GenAI tools were selected for their flexibility and capacity to be applied to different stages of the instructional design (Kumar et al., 2024). During the program, the lecturers were shown each tool as part of an instructional design event but were given specific examples that could be applied to all other events. Accordingly, we used a TPACK model profile for lecturer training focused on flexible tools, as recommended by Harris and Hofer (2017). The lecturers did not find it difficult to combine knowledge that was purely technological with knowledge linked to a pedagogical content approach. In this regard, our results contradict those reported by Miguel-Revilla et al. (2020), who presented a training program based on TPACK for initial lecturer training and found lower levels in the technological components than in the pedagogical ones. It is also worth highlighting that there was a significant improvement in digital competence regarding content creation and evaluation, which are two of the areas where other studies have shown a lower level of competence among lecturers (Fernández Miravete & Prendes Espinosa, 2021; Marín Suelves et., 2022).

This paper presents an updated concept of lecturers' digital competence, emphasizing the knowledge and use of GenAI tools to support educators, as highlighted by Ayuso-del Puerto and Gutiérrez-Esteban (2022). These authors advocate for virtual training that incorporates GenAI tools into initial teacher education, enabling students to design educational resources using such technologies. Due to their flexibility, GenAI tools offer significant pedagogical potential. In our program, they have been integrated into various instructional design components, thereby training teachers to use them for brainstorming, creating, and updating content creation, learning experiences, questionnaires, and evaluation rubrics (Sullivan et al., 2023; Vidal et al., 2024).

Additionally, lecturers shared the conversations they held with GenAI tools through activity submissions, allowing for the analysis and evaluation of these interactions. Consequently, they gained awareness regarding the importance of subject matter knowledge to obtain high-quality outputs from GenAI tools (Gallent-Torres et al., 2023), and of the need to assess and critically reflect on AI-generated content (Kasneci, 2023). To this effect, lecturers are now equipped to instruct their students on the responsible and critical use of GenAI, emphasizing the importance of subject matter knowledge, which is essential to identify inaccuracies and biases (Stojanov, 2023).

In summary, the training program evaluated has successfully integrated GenAI tools into teaching practices, in line with the recommendations of Alenezi et al. (2023) and Ayuso-del Puerto and Gutiérrez-Esteban (2022).

The following section presents the conclusions derived from this study, which have been developed based on the stated objectives and address the research questions posed. They synthesize the main findings obtained from the data analysis and offer an integrated perspective on the most relevant aspects identified.

Conclusion

We conclude that the intervention presented, based on the interaction of technological, pedagogical, and content knowledge, and grounded in the TPACK model and the framework for digital competence recommended by INTEF (2022), has proven effective. It has led to a considerable improvement in digital competence in a virtual environment. In these environments, technology broadens opportunities to introduce active learning models that focus on the students (Balladares-Burgos & Valverde-Berrocoso, 2022; Demeshkant et al. 2022). This improvement takes into account knowledge of the most effective methodologies for teaching specific content, applied to the design of particular teaching and learning scenarios. It also involves selecting the most appropriate technological tools to enhance students' comprehension and mastery of specific content. It involves, in essence, learning to use technology so as to produce an instructional design that makes the students' teaching/learning process interactive, meaningful, and deep (León Naranjo, 2024). Moreover, the training program was used in different areas of knowledge, thereby enhancing its potential for lecturers in digital competence (Binjha et al. 2023; Valtonen et al. 2017). In conclusion, the lecturers were trained to effectively integrate different digital tools and generative GenAI into instructional design, thereby helping to improve digital competence adapted to present-day reality.

In terms of the limitations of this paper, we would emphasize that the intervention was conducted with 78 lecturers, a sample size that we could consider to be relatively small and restricted to a certain context, which limits generalization of the results. Nonetheless, it is worth noting that one of the objectives of this study was to analyze the effects of an intervention with a specific focus. Furthermore, the evaluation of lecturers' digital competence was analyzed through their self-perception, which could produce a higher level of digital competence than the actual level achieved (Viñoles-Cosentino et al., 2021; Zhao et al., 2021). Nevertheless, our research has evaluated the improvement in digital competence by comparing the results that were established before and after the intervention, thereby reducing the difference between the perceived digital competence and that which was actually achieved (Muñoz & Ruiz-Domínguez, 2021).

A series of recommendations have been made for the design of training programmes to improve the digital competence of online lecturers:

- Integrate the use of digital tools into instructional design.
- Select free, easy-to-use, and flexible digital tools, i.e., tools that can be integrated into any phase of instructional design.
- Apply the phases of instructional design and digital tools, contextualizing them in the subjects they teach.

Finally, it is worth mentioning that this training program will be conducted again during this academic year, which will provide the opportunity to continue research into the evaluation of digital competence using proposals such as this one, whilst combining quantitative and qualitative methods.

Acknowledgements

We would like to express our gratitude to the International University of La Rioja for the support provided for our research. We would also like to thank the University of Granada for their collaboration in this work within the framework of a research stay.

Ethics

This work was reviewed and approved by the UNIR Ethics Committee (PI: 098/2023).

Funding

This paper received funds from the Research Project ‘Metodologías activas con tecnologías inmersivas para el desarrollo de competencias profesionales en la formación de futuros docentes [Active methodologies with immersive technologies for the development of professional skills in the training of future teachers] (MATICO)’, reference PP-2023-14, awarded in response to the call for UNIR Proprietary Research Projects 2023 issued by the Universidad Internacional de La Rioja (UNIR).

Availability of data and materials

The data sets generated and/or analyzed during the present study are not publicly available due to personal data protection but can be requested from the corresponding author upon reasonable request.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

References

Alenezi, M., Mohamed, A. M., & Shaaban, T. S. (2023). Revolutionizing EFL special education: How ChatGPT is transforming the way teachers approach language learning. *Innoeduca. International Journal of Technology and Educational Innovation*, *9*(2), Article 2. https://doi.org/10.24310/innoeduca.2023.v9i2.16774

Ayuso-del Puerto, D., y Gutiérrez-Esteban, P. (2022). La Inteligencia Artificial como Recurso Educativo durante la Formación Inicial del Profesorado. *RIED-Revista Iberoamericana de Educación a Distancia, 25*(2), 347-362. https://doi.org/10.5944/ried.25.2.32332

Baena-Morales, S., Martinez-Roig, R., & Hernádez-Amorós, M.J (2020). Sustainability and educational technology— A description of the teaching self-concept. *Sustainability*, *12*(24), 10309. https://doi.org/10.3390/su122410309

Balladares, J. (2018). Diseño pedagógico de la educación digital para la formación del profesorado. RELATEC. *Revista Latinoamericana de Tecnología Educativa, 17*(1), 41-60. https://doi.org/10.17398/1695-288X.17.1.41

Balladares, J. (2020). Una educación remota en tiempos de contingencia académica. *Revista Andina, 2*, 29-35. Universidad Andina Simón Bolívar. https://tinyurl.com/y6t3asl7

Balladares-Burgos, J. y Valverde-Berrocoso, J. (2022). El modelo tecnopedagógico TPACK y su incidencia en la formación docente: una revisión de la literatura. *RECIE. Revista Caribeña de Investigación Educativa*, *6*(1), 63-72. https://doi.org/10.32541/recie.2022.v6i1.pp63-72

Banoy-Suarez, W., & González-Reyes, R. A. (2024). Analysis of Frameworks for Digital Skills Training for Secondary School Teachers: A Systematic Review. *TEM Journal, 13*(2), 1038. https://doi.org/10.18421/TEM132-18

Barragán Sánchez, R., Llorente Cejudo, M. D. C., Aguilar Gavira, S. y Benítez Gavira, R. (2022). Autopercepción inicial y nivel de competencia digital del profesorado universitario. *Texto libre, 15*, 1-24. https://doi.org/10.35699/1983-3652.2022.36032

Binjha, P. B., Das, B. C., Dansana, A., & Das, B. K. (2023). Pedagogical innovation of TPACK based K-4 learning transaction model in science and social sciences. *Asian Journal of Education and Social Studies*, *39*(1), 42-52. https://doi.org/10.9734/AJESS/2023/v39i1838

Cabero, J. y Barroso, J. (2016). Formación del profesorado en TIC: una visión del modelo TPACK. *Cultura y Educación*, *28*(3), 633–663. https://doi.org/10.1080/11356405.2016.1203526

Cabero-Almenara, J., Barroso-Osuna, J., Gutiérrez-Castillo, J. J. y Palacios-Rodríguez, A. (2020). Validación del cuestionario de competencia digital para futuros maestros mediante ecuaciones estructurales. *Bordón. Revista De Pedagogía, 72*(2), 45-63. https://doi.org/10.13042/Bordon.2020.73436

Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Palacios-Rodríguez, A., & Barroso-Osuna, J. (2021). Comparative European DigCompEdu Framework (JRC) and Common Framework for Teaching Digital Competence (INTEF) through expert judgment. *Texto Livre: Linguagem e Tecnologia, 14*(1). http://doi.org/10.35699/1983-3652.2021.25740

Cadena, S. (2022). Modelo TPACK en el proceso de enseñanza - aprendizaje de los estudiantes de la Unidad Educativa Barreiro, Babahoyo, periodo 2020-2021. Repositorio Universidad Técnica de Babahoyo. http://dspace.utb.edu.ec/bitstream/handle/49000/11147/C-UTB-CEPOS-TIE000022.pdf?sequence=1&isAllowed=y

Cacho, R. (2024). Integrating Generative AI in University Teaching and Learning: A Model for Balanced Guidelines, *Online Learning, Volume28*(3), 55-81. https://doi.org/10.24059/olj.v28i3.4508

Carpenter, J. P., Rosenberg, J. M., Kessler, A., Romero-Hall, E., & Fischer, C. (2024). The importance of context in teacher educators' professional digital competence. *Teachers and Teaching*, *30*(4), 400–416. https://doi.org/10.1080/13540602.2024.2320155

Cattaneo, A.P., Antonietti, C., & Rauseo, M. (2022). How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors. *Computers & Education*, *176*, 104358. https://doi.org/10.1016/j.compedu.2021.104358

Cejas-León, R. y Navío Gámez, A. (2018). Formación en TIC del profesorado universitario. Factores que influyen en la transferencia a la función docente. *Profesorado*, *22*(3), 271–293. https://doi.org/10.30827/profesorado.v22i3.8002

Demeshkant, N., Trusz, S., & Potyrała, K. (2022). Interrelationship between levels of digital competences and Technological, Pedagogical and Content Knowledge (TPACK): a preliminary study with Polish academic teachers. *Technology, Pedagogy and Education*, *31*, 579 - 595. https://doi.org/10.1080/1475939X.2022.2092547.

Dervenis, C., Fitsilis, P. & Iatrellis, O. (2022). A review of research on teacher competencies in higher education. *Quality Assurance in Education, 30*(2), 199-220. https://doi.org/10.1108/QAE-08-2021-0126

Ellis, A. R., & Slade, E. (2023). A New Era of Learning: Considerations for ChatGPT as a Tool to Enhance Statistics and Data Science Education. *Journal of Statistics and Data Science Education, 31*(2), 1-10. https://doi.org/10.1080/26939169.2023.2223609

European Commission: Joint Research Centre, Redecker, C., & Punie, Y. (2017). *European framework for the digital competence of educators: DigCompEdu*, (Y.Punie,edito) Publications Office. https://data.europa.eu/doi/10.2760/159770

Fernández Miravete, A.D. y Prendes Espinosa, M. P. Evaluación de la competencia digital de una organización educativa de enseñanza secundaria a partir del modelo DigCompOrg. *Revista Complutense de Educación*, *32*(4), 651-661. https://doi.org/10.5209/rced.70953

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology*: *General, 141*(1), 2-18. https://doi.org/10.1037/a0024338

Gagné, R.M., & Dick, W. (1983). Instructional Psychology. *Annual Review of Psycho*logy, *34*, 261-195. https://doi.org/10.1146/annurev.ps.34.020183.001401

Gallent-Torres, C., Zapata-González, A. y Ortego-Hernando, J.L. (2023). El impacto de la inteligencia artificial generativa en educación superior: una mirada desde la ética y la integridad académica. *RELIEVE, 29*(2), art. M5. http://doi.org/10.30827/relieve.v29i2.29134

García-Peñalvo, F. J. (2023). La percepción de la Inteligencia Artificial en contextos educativos tras el lanzamiento de ChatGPT: disrupción o pánico. *Education in the Knowledge Society (EKS)*, *24*, e31279. https://doi.org/10.14201/eks.31279

García-Ruiz, R. y Pérez Escoda, A. (2021). La competencia digital docente como clave para fortalecer el uso responsable de Internet. *Campus Virtuales 10*(1), 59-71. http://uajournals.com/ojs/index.php/campusvirtuales/article/view/781

García-Ruiz, R., Buenestado-Fernández, M. y Ramírez-Montoya, M.S. (2023). Evaluación de la Competencia Digital Docente: instrumentos, resultados y propuestas. Revisión sistemática de la literatura. *Educación XX1, 26*(1), 273-301. https://doi.org/10.5944/educxx1.33520

González-Pérez, P. y Marrero-Galván, J. J. (2023). Diseños TPACK de futuros docentes e influencia de la competencia digital y del engagement académico. *Estudios Pedagógicos*, *49*(3), 395–411. https://doi.org/10.4067/S0718-07052023000400395

Hämäläinen, R., Nissinen, K., Mannonen, J., Lämsa, J., Leino, K., & Taajamo, M. (2021). Understanding teaching professionals' digital competence: What do PIAAC and TALIS reveal about technology-related skills, attitudes, and knowledge? *Computers in Human Behavior*, *117*. https://doi.org/10.1016/j.chb.2020.106672

Harris, J. B., & Hofer, M. J. (2017). "TPACK stories": Schools and school districts repurposing a theoretical construct for technology-related professional development. *Journal of Research on Technology in Education*, *49*(1-2). https://doi.org/1-15. 10.1080/15391523.2017.1295408

INTEF. (2022). *Marco de referencia de la Competencia Digital del docente*. Instituto Nacional de Tecnologías Educativas y Formación del Profesorado.

Jiménez-Hernández, D., González-Calatayud, V., Martínez-Mayoral, M. A., & Morales, J. (2021). La mejora de la competencia digital de los futuros docentes de secundaria: una experiencia en la Universidad Miguel Hernández. *Aloma: revista de psicologia, ciències de l'educació i de l'esport Blanquerna*, *39*(2), 53-62. https://doi.org/10.51698/aloma.2021.39.2.53-62

Kasneci, E., et. al. (2023). ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education. Learning and Individual *Differences, 103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70. https://www.citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogicalcontent-knowledge/

Koehler, M. J., Mishra, P., & Cain, W. (2015). ¿Qué son los saberes tecnológicos y pedagógicos del contenido (TPACK)? *Virtualidad, educación y ciencia, 6(*10), 9-23. https://doi.org/10.60020/1853-6530.v6.n10.11552

Koh, J. H. L., Chai, C. S., & Lim, W. Y. (2017). Teacher Professional Development for TPACK- 21CL: Effects on Teacher ICT Integration and Student Outcomes. *Journal of Educational Computing Research, 55*(2), 172-196. https://doi.org/10.1177/0735633116656848

Kumar, S., Gunn, A., Rose, R., Pollard, R., Johnson, M., & Ritzhaupt, D. (2024). The role of instructional designers in the integration of generative artificial intelligence in online and blended learning in higher education. *Online Learning, 28*(3), 207-231. https://doi.org/10.24059/olj.v28i3.4501

León Naranjo, J. (2024). El modelo Conocimiento Tecnológico Pedagógico y de Contenido (TPACK): una estrategia para potenciar las competencias digitales de los docentes. *LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades 5*(4)*, 2079 – 2094.* https://doi.org/10.56712/latam.v5i4.2395

Maiier, N., & Koval, T. (2021). How to develop digital competence in pre-service FL teachers at University level. *Advanced Education, 8*(18), 11–18. https://doi.org/10.20535/2410-8286.227639

Marín Suelves, D., Gabarda Méndez, V. y Ramón-Llin Mas, J. A. (2022). Análisis de la competencia digital en el futuro profesorado a través de un diseño mixto. *Revista de Educación a Distancia (RED), 22*(70). https://doi.org/10.6018/red.523071

Martín Párraga, L., Llorente Cejudo, C. y Barroso Osuna, J. (2022). Validación del Cuestionario de Registro DigCompEdu mediante Ecuaciones Estructurales: Un Estudio en una Universidad del Perú. *Education Sciences*, *12*, 574. https://doi.org/10.3390/educsci12080574

Mas García, V., Gabarda Méndez, V. y Peirats Chacón, J. (2023). Formação e competência digital de professores do Ensino Médio na Espanha. *Texto Livre: Linguagem e Tecnologia, 16*. https://doi.org/10.1590/1983-3652.2023.44851

Melash, V.D., Molodychenki, V.V., Huz, V.V., Varenychenko, A.B., & Kirsanova, S.S. (2020). Modernization of education programs and formation of digital competences of future primary school teachers. *International Journal of Higher Education, 9*(7), 377-386. https://doi.org/10.5430/ijhe.v9n7p377

Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. (2020). Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. *Australasian Journal of Educational Technology*, *36*(2), 1–12. https://doi.org/10.14742/ajet.5281

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers' college record, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.0068

Muñoz F.J.R., & Ruiz-Domínguez, M.D.M. (2021). A competência digital dos profesores de literatura no ensino médio na Espanha. *Texto Livre: Linguagem e Tecnología, 14*(3), e31351. https://doi/org10.35699/1983-3652.2021.31351

Ortiz, J. de J. A., Hernández, S. M. de la L. V., Navarro-Illana, P., Martín-Palomino, A. P., Navarro-Illana, E., & Martínez, G. D. O. (2025). Design of a B-Learning Workshop for Teacher Digital Skills Training. *Revista De Gestão Social E Ambiental, 19*(1), e010668. https://doi.org/10.24857/rgsa.v19n1-005

Palacios-Rodríguez, A., Llorente-Cejudo, C., Lucas, M., & Bem-haja, P. (2025). Macroevaluación de la competencia digital docente. Estudio DigCompEdu en España y Portugal. *RIED-Revista Iberoamericana De Educación a Distancia, 28*(1), 177–196. https://doi.org/10.5944/ried.28.1.41379

Pizà-Mir, B., Moreno-Vecino, B., & Monserrat-Monserrat, M.-V. (2023). Interest of nonuniversity teachers in educational research projects. *REIRE Revista d'Innovació I Recerca En Educació, 16*(2), 1–13. https://doi.org/10.1344/reire.42438

Stojanov, A. (2023). Learning with ChatGPT 3.5 as a more knowledgeable other: an autoethnographic study. *International Journal of Educational Technology in Higher Education*, *20*(35), 1-17. https://doi.org/10.1186/s41239-023-00404-7

Sullivan, M., Kelly, A., & McLaughlan, P. (2023). ChatGPT in higher education: Considerations for academic integrity and student learning. *Journal of Applied Learning & Teaching, 6*(1), 31-40. https://doi.org/10.37074/jalt.2023.6.1.17

Valtonen, T., Sointu, W., Kukkonen, J., Kontkanen, S., Lambert, M., & Mäkitalo-Siegl, K. (2017). TPACK actualizado para medir las habilidades del siglo XXI de los profesores en formación. *Australasian Journal of Educational Technology, 33*(3), 15-31. https://doi.org/10.14742/ajet.3518

Valverde, J. y Balladares, J. (2017). Enfoque sociológico del uso del b-learning en la educación digital del docente universitario. *Sophia: colección de Filosofía de la Educación, 23*(2), 123-140. https://doi.org/10.17163/soph.n23.2017.04

Vidal, J., Llorens-Largo, F., & García-Peñalvo, F. J. (2024). The new reality of education in the face of advances in generative artificial intelligence. *RIED Revista Iberoamericana de Educación a Distancia, 27*(1). https://doi.org/10.5944/ried.27.1.37716

Viñoles-Cosentino, V., Esteve-Mon, F. M., Llopis-Nebot, M. Á. y Adell-Segura, J. (2021). Validación de una plataforma de evaluación formativa de la competencia digital docente en tiempos de Covid-19. *RIED-Revista Iberoamericana de Educación a Distancia*, *24*(2), 87–106. https://doi.org/10.5944/ried.24.2.29102

Vowell, K. S. (2024). Collaboration, connection, and culture: Understanding the impact of institutional culture on online teaching in higher education. *Online Learning Volume, 28*(3), 299-315. https://doi.org/10.24059/olj.v28i3.4561

Wach, K et al. (2023). The dark side of generative artificial intelligence: A critical analysis of controversies and risks of ChatGPT. *Entrepreneurial Business and Economics Review*, *11*(2), 7-24. https://doi.org/10.15678/EBER.2023.110201

Zhao, Y., Pinto Llorente, A.M., Sánchez Gómez, M.C., & Zhao, L. (2021). The impact of gender and years of teaching experience on college teachers' digital competence: An empirical study on teachers in Gansu Agricultural University. *Sustainability*, *13*, 4163. https://doi.org/10.3390/su13084163