Orchestrating the TPACK of University Professors, in Order to generate AI Prompts that Improve the Initial Training

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Abstract: This article presents a study focused on the articulation of technological, pedagogical, and content knowledge (TPACK) among university faculty members, with the aim of generating contextualized pedagogical proposals using generative artificial intelligence (AI) tools. Through the analysis of concept maps and interviews with twenty professors from diverse disciplines, key variables in the teaching-learning process were identified, as well as the interactions between different types of TPACK knowledge. The novelty of this study lies in the proposed design of prompts aimed at IAG systems, which allow the generation of contextualized pedagogical proposals. The cross-analysis between types of TPACK knowledge and contextual variables revealed combinations with high training potential. The study proposes new lines of research that integrate the TPACK model and the validation of prompts as training tools. Overall, the extracted variables have been used as AI indicators to improve initial teacher training. However, a solid framework is offered for integrating emerging technologies to improve the pedagogical and digital competence of university faculty members, helping to reduce pedagogical frailty and improve technological integration in educational practice.

Keywords: Artificial Intelligence, TPACK, Pedagogic Frailty, TPACK, Superior Education, Concept Maps, PROMPT.

1. Introduction

The integration of artificial intelligence (AI) in educational settings is heralding a significant paradigm shift that is reshaping teaching and learning processes. This transformation is characterized by a move from traditional, teacher-centered methodologies to more dynamic, learner-centered approaches. As AI technologies become increasingly prevalent, they are poised to enhance personalized learning experiences, improve educational outcomes, and foster innovative pedagogical strategies (García-Peñalvo, 2023; Luckin & Holmes, 2016; Rebollo-Catalán & Vico-Bosch, 2014; Saz-Pérez, Pizá-Mir & Lizana Carrió, 2024).

One of the key features of this paradigm shift is the ability of AI to provide personalized learning experiences that address individual student needs. To do this, educators need to feel empowered (Brynjolfsson & McAfee, 2014).

However, professors have pedagogical fragility (De Benito, Lizana & Salinas, 2017) and not all have optimal TPACK competence. This transition is not without challenges.

The research focuses on teacher training as a determining factor for teaching innovation, in order to design an appropriate environment in accordance with emerging teaching models in ICT, now with the inclusion of AI.

Besides, Artificial Intelligence (AI) has emerged as a revolutionary technology that has transformed many aspects of our daily lives, and education is no exception

(Brade et al., 2023; Dwivedi et al., 2023; Jukiewicz, 2024). The configuration of initial teacher training would benefit from AI if prompts were used to generate training based on the TPACK model and reduce the pedagogical fragility of professors (Kinchin et al., 2016).

However, the works that study TPACK, pedagogical fragility or the initial training of professors are isolated, without the aforementioned points being well connected. However, if we add the component of the use of artificial intelligence, specifically, the focus on the design of prompts (White et al., 2023; Zawacki-Richter et al., 2019) based on the relationship of the previous variables, it may be, to say the least, interesting. In this way, the study seeks to analyze which prompts such as instructions or questions that are used to interact with artificial intelligence systems, can be carried out, based on a prior collection of TPACK knowledge from the teacher, to reduce fragility and generate optimal content in education.

All of this, can require the search for methodologies to capture expert knowledge, systems management analysis and knowledge representation.

1.1. Using the AI-enriched TPACK Framework

Delimiting TPACK in synthesis (Ching Sing, Joyce Hwee Ling & Chin-Chung, 2013; Koehler, Mishra & Cain, 2013) it refers to integrating ICT (Information, Communication, Technology) Educational Technology into classroom teaching and learning. Its main components are: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK). The interactions of these three basic forms of knowledge give rise to pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and TPACK which is the intersection of all three, representing technological, pedagogical, content knowledge. This is a powerful framework which has many potential uses in the research and development relating to ICT use in education (Ching Sing et al., 2013; Ku et al., 2021; Rosenberg & Koehler, 2015).

In Benson and Ward (2013) research we find a similar experience to the one being presented. TPACK was used as a framework to evaluate teaching expertise in higher education. An individual TPACK profile was created with information from interviews and non-participant observation. Based on it, it was found about TPACK knowledge interaction. Technology knowledge refers to how they use certain tools with no balanced or integrated profile to TPACK. While professors who were able to articulate and understand their pedagogical knowledge, they were more able to demonstrate TPACK integration. This aspect is seen in different studies (Alemán-Saravia, Deroncele-Acosta & Robles-Mori, 2023; Paidicán & Arredondo, 2023).

Using the TPACK model as a framework for professors to document their knowledge gives an opportunity to orchestrate factors from the model (Lizana Carrió, 2021) with the ones represented in the concept maps developed from the interviews performed to each professor.

In the current context, generative artificial intelligence (GAI) represents an emerging dimension of Technological Knowledge (TK) that transforms the TPACK model into a dynamic and adaptive structure. As proposed by Celik (2023) through the concept of intelligent-TPACK, or in studies such as that of (Ren & Wu, 2025) AI

not only expands the possibilities of TK application, but also redefines the interactions between technology, pedagogy, and content. This evolution enables teachers not only to use digital tools, but to collaborate with intelligent systems capable of generating content, strategies, and assessments tailored to their specific contexts.

Generative artificial intelligence (GAI), can play a key role as a cognitive mediator in the development of TPACK knowledge. Its impact is particularly evident in three core components:

- TK (Technological Knowledge): AI enables teachers to access, create, and adapt digital resources automatically, facilitating mastery of technological tools without requiring advanced technical training.
- TPK (Technological Pedagogical Knowledge): AI can generate personalized instructional strategies, such as active learning activities, formative assessment, or methodologies like the Flipped Classroom, aligned with the teacher's pedagogical goals (Holmes, Bialik & Fadel, 2019).
- TCK (Technological Content Knowledge): AI systems can generate discipline-specific content adapted to students' levels, supporting the effective integration of technology in content delivery (Chen, Chen & Lin, 2020; Zawacki-Richter et al., 2019).

This cognitive mediation allows teachers to act as designers of learning experiences, supported by AI as a pedagogical assistant capable of interpreting prompts and offering contextualized solutions. In this sense, AI does not replace the teacher, but amplifies their capacity for planning, innovation, and adaptation.

2. Methodological Approach

In order to apply TPACK framework to analyze university professors' expert knowledge, a methodology based on design and development (de Benito Crosetti & Salinas Ibáñez, 2016; McKenney & Reeves, 2012; Plomp, 2010). Following Reeves (2000, 2006). This research was done in different phases whose objective was to deeply comprehend the different factors that take part and interact in the teaching/learning process. Factors that directly relate to professors' knowledge, in this case TPACK, the context where the learning process takes place, students,

2.1. The Study Phases

Phase I. Identifying Professor who use ICT for Teaching

The first study phase was to identify professors using ICT for their teaching. Universitat de les Illes Balears (UIB) Campus Extens was visited to consult their good practice catalog, which allowed besides knowing about the professors, to extract the implicit knowledge, with respect to their good practice (Lizana, 2012).

From this analysis the following factors are obtained:
- USAGE. What use does professors give to their practice, what is the purpose of using it in class.
- DESCRIPTION. Explaining the practice.
- COORDINATION/ORGANIZATION. Explains the way in which students participate.

Phase II. TPACK Model Factors Definition

Based on the factors from the good practice analysis, an interview was made to professors in order to capture their TPACK knowledge with respect to the good practice done. These interviews were performed with a double purpose: on one side they were used to corroborate the explicit knowledge extracted in the previous phase from the good practice registry; and on the other side to distinguish the identifying items which allowed to extract the implicit knowledge.

The analysis and detail for each of the knowledge that make up the TPACK model are based on definitions used by different authors (Harris & Hofer, 2009; Mishra & Koehler, 2006, 2008; Shulman, 1986). As a synthesis the identified factors that describe each of the knowledge that include TPACK model; such as Formation professors experience, knowledge on the topic, ICT usage abilities, teaching/learning methods and techniques and planning.

Phase III. Context Variable Identification Present at Professors Expert Knowledge Capture

In order to identify contextual elements involved in the teaching/learning process based on ICT, conceptual map generated from professors' interviews were analysed. In the following image the variables collected are established as starting point.

Figure 1: Context Influence on TPACK Knowledge.

Source: http://edt514tpack.wikispaces.com/Context+Influence+on+TPACK
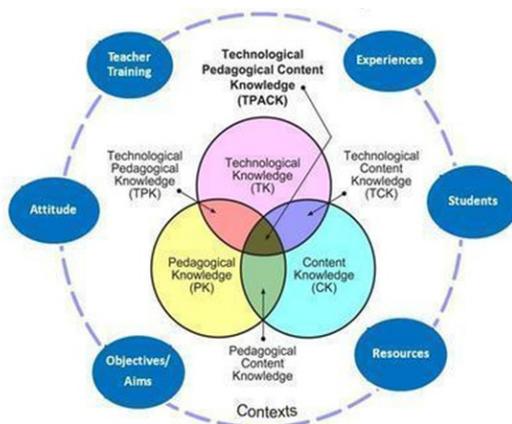
The context variables are:

Table 1: Describing Context Variables. Own Elaboration.

Attitude	Professor's attitude in relation to ICT introduction in teaching.
Students	Students' attitude, to what extent teaching strategy benefits or is accepted by students. When participation or student implication does is supposed.
Experiences	University teaching experience and previous working experience.
Teacher Training	Academic training received to develop pedagogical competence for teaching.
Objectives/Aims	Objectives and competences for teaching and which should be reached by students.
Resources	Resources and materials used for teaching.

Participants

Because this research is an study we adopted a case study approach, so twenty lecturers from one university were invited to participate. They were selected if they had participated or had developed some experience using ICT during teaching, within the institutional project implemented at the university under study (Lizana, 2012).

These participants represented the following discipline areas: nursing, physiotherapy, teacher training, education sciences, language studies, philology, social education, therapeutic pedagogy.

Data Gathering

Qualitative research was used because of its methodological and epistemological basis, which tends to be of an explanation order belonging to theoretical structures.

A semi-structured interview ranged from twenty to thirty was performed with professors participating in the project. At the same time a conceptual map, was made by the interviewer representing teaching practices, in order to learn about professors' interactions and their significance with TPACK.

Analysis of Conceptual Maps

Conceptual map coding processes and analysis generated from the interviews was done using Atlas.ti. Even though the factors extracted from the two firsts phases of the study were used as a category systems, the possibility is open to incorporate new categories with respect to the information from the professors interviewed.

Initial categories used were:
-   About factors extracted from TPACK model: Formation, experience, knowledge on the subject, abilities to use ICT, teaching and learning methods and techniques, planification.
-   About different types of knowledge: TK, TCK, CK, PK, PCK and TPK.
-   About context variables: experiences, students, resources, objectives/aims, attitude, teacher training.

Phase IV. Design and analysis of prompts based on TPACK and AI

With the objective of exploring how generative artificial intelligence (AI) can contribute to the initial training of university professors, to continue the TPACK line of research, and based on the variables and correlation extracted from them a set of prompts, was designed based on the TPACK model, through concept map analysis and interviews. This section describes the methodological procedure followed for their design and the analysis of their pedagogical potential.

Prompt design was based on the triangulation of three main sources:
-   The types of knowledge in the TPACK model (TK, PK, CK, TPK, TCK, PCK, and TPACK).
-   Contextual variables emerging from qualitative analysis (attitude, experience, resources, evaluation, coordination, training, etc.).
-   Real teaching practices described by the twenty professors participating in the study.

Each prompt was designed to activate one or more types of TPACK knowledge, considering a specific contextual variable. For example, a prompt such as: *"Design a Flipped Classroom activity for physiotherapy students using interactive videos to encourage active participation in class"* was constructed to activate TPK knowledge in relation to the 'attitude' variable, inspired by the experience of professor L13.

The prompts were analyzed based on three criteria: the expected response from the AI, the alignment with real teaching practices, and their formative potential. Specifically:

- Expected AI response: The AI's ability to generate coherent, contextualized, and aligned pedagogical proposals with TPACK knowledge was evaluated (with some examples presented in the paper).
- Correspondence with teaching practice: The degree of alignment between the responses generated by the AI and the actual practices described by teachers was examined.
- Training potential: The usefulness of the prompts as a tool for initial teacher training was assessed, especially in improving digital competence and reducing pedagogical weakness.

3. Findings and Discussion

Concept maps analysis has made it possible to establish relations between different factors that intervene in the teaching/learning process. The results presented show the connection between different studied variables and the types of knowledge that TPACK model gathers up. L1, L2, L3, etc. codes represent each participant and are used to show quoting sources from the analyzed maps.

The co-occurrence makes it possible to measure interdependence between two concepts. The value fluctuates between 0 and 1, been nearest to 1 codes the ones with more co-occurrence. In this study co-occurrence has been analyzed from the number of quotes and share different codes.

3.1. Co-occurrence of Technological, Pedagogical and Content Knowledge

First the existing relation between different types of knowledge from the TPACK model, were analysed. In the following table (see Table 3) the frequencies show the number of quotes that each knowledge have and the co-occurrence coefficient between them.

Table 2: Technological, Pedagogical and Content Knowledge Frequencies, quotes and Co-occurrences. Own Elaboration.

	CK	PCK	PK	TCK	TK	TPK
CK		40 - 0.62	78 - 0.92	1 - 0.01 🟡	67 - 0.67	38 - 0.44
PCK	44 - 0.72		34 - 0.41		34 - 0.40	24 - 0.45
PK	70 - 0.75	33 - 0.40		4 - 0.05 🟡	96 - 1.17 🔴	46 - 0.52
TCK	1 - 0.01 🟡		3 - 0.03 🟡		1 - 0.01 🟡	
TK	59 - 0.55	32 - 0.36	83 - 0.87	1 - 0.01 🟡		78 - 1.28 🔴
TPK	34 - 0.38	19 - 0.33	43 - 0.47		77 - 1.24 🔴	

Regarding the Content Knowledge (CK) refers to the particular domain the professor have from a discipline he has to teach. This knowledge includes concepts, principles, theories, ideas, concept maps, schemes, points of view, etc. It has been found that 76 quotes that could be associated with this code. From these with the knowledge that share a greater number of quotes is TPK, followed by TK. CK is obtained in its degree (L1-L20), with its previous working experience to teaching in the university (L7, L8, L9, L10, L11, L14, L15, L16, L18, L19, L20) by taking continuing educational courses like seminars, postgraduate studies (L13, L14, L15, L17, L18, L19), research (L12, L13, L14, L17, L20). On the other hand, CK is represented on courses and materials done by professors for their own teaching.

Pedagogical Content Knowledge (PCK) is the knowledge from a specific area. It focuses on material transformation of the course to teach, which is produced when the professor makes a particular interpretation of the content. The number of quotes included in this category is 29. This type of knowledge presents a major concordance with CK followed by PK. According to interview analysis this type of knowledge mainly collects didactic strategies like study cases, simulated techniques, etc. (L7, L8, L9, L10, L11) and the resource and material development for teaching like clinic cases, photo repository, practical cases, videos, presentations, concept maps (L1, L2, L5, L7, L8, L10, L11, L15). Professors that teach at Education studies were found with PK related to CK, other professors who belonged to different discipline areas, have completed their studies with courses or masters related to their studies and in two cases they have finished an Educational Technology master.

Pedagogical Knowledge (PK) is the abilities and related knowledge to general academic training. It refers to the teaching/learning processes knowledge. Includes general and specific objectives, evaluation criteria, competences, organization variables, etc. They apply to students comprehension of how they learn. A total of 87 quotes related with this knowledge were found, where CK and TK knowledge which show more occurrence. From the interview analysis we can observe that PK is principally related with teaching either face to face, blended or on-line (L2, L3, L4, L9, L12, L18); how are strategies and teaching material applied either theory or practice (L1-L20), the resources and materials used for teaching (L1-L20). With respect to its relation with CK, the quotes that stand out deal with different educational resources, prepared by the professor (L1, L3, L5, L7, L8, L9, L11, L12, L15,) and the ones, as previously mentioned, refer to the training received. 13 quotes were found where PK and TK coincide, these refer to technology use to: apply evaluation strategies (questionnaires, activity delivery, portfolio, etc); different didactic resources (video, conceptual maps, presentations, etc.) class planning (calendar and communication tools like forums, news boards); and the class teaching using institutional LMS (L1-L20).

Technological Content Knowledge (TCK) suppose knowing how to relate all technological knowledge. Professor do not only need to control knowledge on the course they teach, but also to have an expert knowledge of the way technologies can influence in the contents presented. In this case quotes that refer to the use of technology to develop class content related to the discipline, were taken into account. A total of 12 quotes were found (L2, L3, L7, L8, L15) the first to create fragmented movies to transfer content and to develop different types of digital resources; L3 gives a class about learning language and creates videos to show the correct pronunciation; with respect to L7 it develops videos about some practices that the nursing students should do; L8 makes visual presentations; and L15 besides videos and presentations uses concept maps created in collaboration with his students.

Technological Knowledge (TK) is the knowledge in relation to comprehension on ICT use. It refers to the knowledge on tools use and technological resources including general comprehension on how to applied them in an proper. With PK the knowledge with more quotes related (91) that presents a high grade of co occurrence are TPK and PK. These quotes refer to different tools used by professors: communication tools like forums, e-mail, chat, news, twitter, videoconference(L1-L20), for planning like calendars or chronograms (L1, L5), institutional LMS (L1-L20), applications for resource creation and learning materials (L2, L7, L8, L9, L15), to create and share information like conceptual maps, blog, googledrive or dropbox (L2, L14, L15, L18). According to interview responses, the way TK has been mainly acquired has been through self learning (L2, L3, L4, L6, L9, L10, L12, L14, L15, L18) and the courses offered from the same institution (all professors except two mentioned they have trained with the courses offered). 33 quotes were found which coincide with TK and TPK, the majority of them make reference to the use of technologies in didactic strategies, tutoring, or educational resource creation. Also a reference is made to educating in relation to the use of different pedagogical tools like questionnaires, videoconferences or LMS.

Technological Pedagogical Knowledge (TPK): To know how to use ICT on an specific educational subject. Depends on knowledge, advantages and limitations from different technological tools to favor different didactical strategies. The quotes found were 49 associated with this type of knowledge and as it was previously mentioned, they refer mostly to the technology use for teaching (like debate, flipped classroom, practices (L6, L7, L9, L13)); evaluation strategies (auto evaluation, questionnaires, co evaluation, portfolios (L2, L3, L5, L6, L7, L8 L9, L11, L15, L17, L19)); the design and production of teaching resources (L2, L4, L7, L8, L9, L15); and techno-pedagogical origin formation, most of them on courses offered from the same university, others acquired during their academic studies and others through postgraduate and masters (L13, L14, L15, L17, L18, L19).

3.2. Co-occurrence of Context Variables and TPACK

As Lizana Carrió (2021) state one of the research fields which should be taken a closer look is the context variable analysis present in the teaching/learning process which in turn interact with professors TPACK.

First we have tried to establish a series of context variables from concept maps analysis from the interviews. Based on the ones provided in Table 4 which are: attitude, students, teacher training, objectives, resources and materials.

In the same vein from the results described previously, analysis of the existing relation between the different types of knowledge from TPACK model and these variables (table 4).

Table 3: TPACK Quote Frequencies and Co-occurrence with Contextual Variables. Own Elaboration.

	CK	PCK	PK	TCK	TK	TPK
Attitude	11 - 0.14 ●	3 - 0.08	11 - 0.12 ●	6 - 0.33	28 - 0.37 ●	6 - 0.11
Students	15 - 0.17	6 - 0.12	21 - 0.23	4 - 0.12	33 - 0.40	15 - 0.25
Experience	56 - 0.67	24 - 0.35	47 - 0.45	1 - 0.01 ●	36 - 0.30	23 - 0.26
Teacher training	18 - 0.20	15 - 0.34	28 - 0.31	1 - 0.02	17 - 0.16	20 - 0.34
Objectives/aims	2 - 0.03 ●		10 – 0.12 ●	3 – 0.23	7 – 0.08 ●	3 - 0.06 ●
Resources an...	77 - 1.24 ●	31 - 0.51	76 - 1.03 ●	31 - 0.70 ●	99 - 1.80 ●	45 - 0.67

Observing the table, the contextual variable with higher association that relates to TPACK, is the one that refers to resources and materials.

Regarding Attitude, quotes taken into consideration were those where the professor showed an opinion or reflection about ICT use for teaching. 12 quotes were found related to this. Some of them are:

L13 has tried to implement Flipped classroom as a methodology to encourage student participation in face to face classes, but he has found problems to motivate students to participate in this methodology.

L15 uses the blog to develop technical skills with his students and at the same time, evaluate knowledge acquired, but he considers that blog use means an effort and will like to use the tools to facilitate composition. Something similar is presented with respect to video production.

Several professors that tutor final grade works manifest the need to have a space and some tools to better the tutor process (L13, L14, L15, L16, L17, L18, L19, L20).

Even Though it is not related with technology use in the educational process L16 comments that in a university context, non research professors are penalized, thus giving more importance to research over teaching.

At the student variable students attitude has been taken into account, as well as strategies applied by the professor, which imply a student's active role. In this sense 25 quotes were found related with:

- Didactic techniques that favor self work and autoregulation (L5,L6, L7, L13, L16). L5 uses a calendar as a tool to communicate and plan activities that must be completed by students, establishing due dates, adding learning resources. This strategy helps him to plan and organize the class, thus making his teaching more dynamic, face to face, social at the same time self work is promoted. L7 uses study strategy to have students work in groups promoting collaborative work and student autonomy.
- Students' class evaluation. L15 uses concept maps which he builds together with his students, which show a very positive attitude for this strategy, since it lets them have a content scheme and concepts relations which they should learn. L16 uses brainstorming with his students to introduce upgrades to his course. L17 uses rúbrics to evaluate his course.
- Students motivation. L16 refers to "transparent students" to the ones that need to be motivated and involved in the training process L13, as mentioned before he finds difficulties to have student involvement when using flipped classroom.

Experience is the big one of the variables which seems to influence more in CK and also but in a lesser extent PK and PCK. 64 quotes were found related with experience. The majority of professors interviewed has labor experience in its discipline before starting their career as university professors, others entered the university through a collaboration scholarship. Besides the experience from working, some professors manifest that their research project participation helps them better their knowledge on the subject they teach (L12, L13,L14). This variable is very closely related with the formation previously received in discipline as well with pedagogical aspects (L3, L10, L14, L15, L17, L18).

With respect to teacher training, it refers to the formation received as professors. In obtaining a degree, others have taken postgraduate courses and masters, two a master in this sense which was previously mentioned by interviewed professors

some of whom are professors from the education field, so PK was from educational technology.

About objectives, only three professors reference this variable. In L12 case trying to develop analysis capacity from real cases that students must analyse, discuss and write a report. L15 powers aptitud techniques by using a blog. L20 pretends to know the professor's role, incentivize students interests, to better the evaluation system and define concrete tutor functions.

Resources and materials is a variable more related to TPACK and is one of the most associated quoted concepts (63). It refers to different types of means the professor use in the teaching/learning process. It is closely related with the way in which the professor transmits discipline contents (CK), it means elaborated and its usage (TPACK). Related to resources and materials the for these is included. Maps reveal different format usage like: photography and digital image (L2, L9), pdf lectures or web (L1, L9, L11), videos (L2, L7, L8, L9, L10), visual presentations (L7, L8, L11), simulations (L9), conceptual maps (L13). On the other hand this variable presents a narrow link with methods and didactic techniques developed by the professor (PK). Related with this element 27 quotes were found. Some professors reveal LMS usage as a content repository with these resources used by the professor (L1, L3, L6, L7, L17).

Besides the variables described on the context map analysis, another series of variables were found which can help to go in depth on the TPACK framework and the context influence.

These variables are:
- Students grouping. This variable is related to the number of students per subject and how they are grouped to perform different activities (individually, in pairs, small group, medium group and grand group). In this sense several interviewed professors made reference to the didactic strategy used and how were students grouped (L7, L8, L9, L10, L11, L12, L18, L19, L20).
- Institutional project. Professors interviewed belonged to the same university, which includes within its strategic lines, encourage ICT usage for teaching. For this the university has a service that offers: technical and pedagogical support for professors, student support on how to use ICT, technological infrastructure; training courses; and a LMS. It seems this is an important variable to take into consideration since with this service 18 from 20 professors have manifested they received technical support on tools management and also with respect to possibilities and pedagogical ICT exploitation. They all use the same LMS provided by the institution which handles it in a centralized manner in order to serve its users.
- Three professors commented they solicited services from this unit in order to create didactic resources (L2, L4, L6).
- Class atmosphere. Two of the interviewed professor (La, L6) commented this variable in the sense of its relation to pedagogical knowledge. L6 uses discussion forums to ease communication, share opinions and favor group cohesion. L4 proposes developing students personal presentation in videos to better student relations and class atmosphere
- Course and professors coordination. 11 quotes were found related to the need to coordinate contents and activities between subjects from the same study and between professors. In this last case aimed to professors that tutor final grade

projects (L7, L8, L9, L10, L11, L13, L14, L19, L20).
- Evaluation: this variable seems to be important to professors since 57 quotes were found. From these 5 make reference to autoevaluation (L2, L3, L9, L11, L17); 3 to co evaluation (L7, L8), 5 to the use of questionnaires (L2, L5, L6, L7, L19); and 44 on general evaluation aspects like evaluation criteria, techniques, feedback, technology use, etc.
- Flexibility. Independently from the teaching mode either face to face, blended learning or online ICT provides geographical and time-space flexibility.
- Type of learning. Three interviewed professors have referred to the type of learning which promotes the didactic strategy developed: constructivist (L9), significant (L2, L9, L11) and experienced (L9).
- Tutoring and student accompanying: on one side student tutoring in final grade projects have an impact on professors CK. 36 quotes were found which could relate with this variable. Some of them describe the tools utilized in order to perform tutoring (chat, email, forum, phone), other of the criterias and processes followed or the need to coordinate with other professors.

3.3. Proposal Framework for Teacher Training based on TPACK and Contextual Analysis

Based on the analysis of the TPACK knowledge types and the contextual variables identified in the interviews and concept maps, a reorganized proposal of prompts aimed at initial teacher training has been developed. This proposal aims to facilitate the use of generative artificial intelligence (GAI) tools to generate contextualized pedagogical responses aligned with teachers' actual practices. The prompts have been grouped into three thematic blocks: According to the TPACK knowledge types, based on contextual variables, and based on specific teaching practices. This structure allows for better adaptation of the prompts to different training scenarios and reinforces their potential as a tool for designing AI-mediated learning experiences.

3.4. Prompts Based on TPACK Knowledge Types

These prompts have been designed to activate specific components of the TPACK model with the greatest needs analyzed in the interviews. They are useful for generative AI tools, to generate pedagogical proposals aligned with the instructor's profile.

CK + TPK
Prompt: How does disciplinary knowledge (CK) influence the implementation of pedagogical-technological strategies (TPK) in university teaching?
AI-based tool: Can generate activities that integrate disciplinary content with active, technology-mediated methodologies (e.g., simulations, flipped classrooms).

PCK
Prompt: Describes effective strategies that instructors use to transform content into accessible formats for students.
AI-based tool: Can propose didactic adaptations based on the type of content and student level.

PK + TK

Prompt: How is pedagogical knowledge (PK) affected by the use of technology in the classroom? Includes examples of tools and strategies.

AI-based tool: Generation of resources such as digital rubrics, forums, calendars, and interactive activities.

TCK

Prompt: How does technological-disciplinary knowledge (TCK) influence the integration of technology into course content?

AI-based tool: Creation of audiovisual materials, interactive presentations, and discipline-specific simulations.

3.5. Prompts based on Analyzed Contextual Variables

We believe that these indicators would allow AI to generate proposals tailored to the teacher's educational environment.

Teacher Attitude

Prompt: How does a teacher's attitude toward ICT influence the implementation of methodologies such as the flipped classroom?

AI-based tool: Suggestions for overcoming resistance, motivating students, and adapting methodologies.

Assessment

Prompt: What formative assessment methods do teachers use and how can they be enhanced with technology?

AI-based tool: Designing rubrics, self-assessments, peer-assessments, and automated feedback.

Professional Experience

Prompt: How does previous work experience influence the development of teachers' CK and PCK?

AI-based tool: Generating practical cases based on real-life scenarios.

Teaching Coordination

Prompt: What strategies can facilitate coordination between teachers in interdisciplinary modules?

AI-based tool: Joint planning proposals, shared schedules, and collaborative tools.

3.6. Prompts Based on Specific Teaching Practices

These prompts are inspired by actual practices described by the interviewed teachers.

Student Motivation

Prompt: What strategies can help motivate "transparent" or unengaged students?

AI-based tool: Gamified activities, personalized feedback, collaborative dynamics.

Student Grouping

Prompt: How does the way students are grouped influence the effectiveness of active methodologies?

AI-based tool: Design activities according to grouping type (individual, pairs, groups).

Tutoring and Support

Prompt: What digital tools can improve the tutoring process for final projects?

AI-based tool: Generation of guides, rubrics, communication channels, and personalized follow-up.

3.7. Cross-analysis of TPACK–AI Prompts and Contextual Variables

The relationship between the components of the TPACK model, contextual variables, examples of indications for IA, expected responses and their alignment with current teaching practices is presented below. The results show that AI can act as a cognitive mediator in the development of TPACK knowledge, offering responses adapted to the real needs of professors and promoting pedagogical reflection. The full set of indications and their analysis are presented below.

Table 4: Prompts Based on TPACK and Contextual Variables. Own Elaboration.

TPACK Component	Contextual Variable	Prompt Example	Expected AI Response	Alignment to Teaching Practice
TPK	Attitude of Professors	Design a Flipped Classroom activity for physiotherapy students using interactive videos to encourage active participation.	Activity with multimedia resources, evaluation rubrics, discussion forum, and automated feedback.	Reflects L13's attempt to use Flipped Classroom; AI can adapt to student profiles.
TCK	Resources and Materials	Generate a lesson plan for a language class using digital tools to teach pronunciation and listening.	Activities with recordings, phonetic analysis, interactive exercises, and feedback.	L3 uses videos for pronunciation; AI enriches with adaptive exercises.
PK	Evaluation	Propose formative assessment strategies including self-assessment, peer review, and digital rubrics.	Rubrics, self-assessment forms, peer review templates, and feedback suggestions.	L2, L3, L7, L8 use these strategies; AI systematizes and reduces workload.
CK	Professional Experience	Design a case-based learning activity for nursing students integrating the professor's field experience.	Clinical case simulations, analysis guides, reflection questions, and evaluation rubrics.	L7 and L8 use real cases; AI structures and diversifies them.
TPACK	Teacher Coordination	Design an interdisciplinary module integrating pedagogy, technology, and language with three instructors.	Collaborative activities, shared schedule, communication tools, and joint evaluation.	L7-L14 highlight coordination needs; AI supports joint planning.
TK	Teacher Training	Suggest a self-training path for university professors to improve digital competence in LMS, Assessment tools, and content creation.	List of resources, recommended courses, tutorials, and practical activities.	All professors mention institutional training; AI personalizes based on needs.

The cross-analysis of prompts designed from the TPACK model and the contextual variables identified in the study reveals relevant patterns that reinforce the usefulness of generative artificial intelligence (GAI) as a cognitive mediator in teacher training. The main findings are:

1. Balanced coverage of TPACK components: Each knowledge type (TPK, TCK, PK, CK, TPACK, TK) is represented, demonstrating the cross-cutting applicability of AI.
2. Diversity of contextual variables: Variables such as attitude, resources, evaluation, experience, coordination, and training allow prompts to be adapted to different educational scenarios.

3. Significant combinations: High-potential pedagogical combinations are identified, such as TPK + attitude or PK + evaluation, where AI can systematize complex processes.
4. Training implications: Prompts help translate real experiences into scalable proposals, personalize training paths, and support instructional planning.

This analysis reinforces the idea that AI, when articulated with TPACK knowledge and properly contextualized, can become a powerful tool for educational innovation.

4. Conclusion

This case study research has allowed us to go into detail on the TPACK components framework. Using the 20 university professors' interviews and the concept maps analysis generated with the professors, it was possible to establish the existing relations between different variables present at the teaching/learning process. Most of the variables identified using the interviews are positioned in the micro level referred by Porras-Hernández and Salinas-Amescua (2013) and Rosenberg and Koehler (2015). It is noted that professors suffer from pedagogical fragility since they may have been poorly trained or they may not be equipped with the best technological and appropriate pedagogical skills (Cabero-Almenara, Arancibia & Del Prete, 2019; De Benito et al., 2017; Lizana Carrió, 2021).

Findings of this study, just as the ones performed by Anderson, Barham and Northcote (2013), prove that TPACK framework could be used as an analysis tool to study professors' competencies (Ren & Wu, 2025) relating to the use of ICT, specifically based on AI, for teaching. The analysis type performed allows us to deepen the process to learn how professors are applying the technology. Currently, faced with the challenges of artificial intelligence, we have the study of Saz-Pérez et al. (2024) and Saz-Pérez et al. (2025). The analysis of the co-occurrence of context variables and the TPACK framework reveals several critical insights into initial teacher training. Firstly, a professor's attitude towards information and communication technology (ICT) significantly impacts their teaching methodologies. Positive attitudes facilitate the effective implementation of innovative strategies, such as the Flipped Classroom, while negative attitudes can impede student engagement.

Motivating students to participate in active learning presents substantial challenges for educators. The findings suggest that strategies fostering relatable content and a collaborative environment are essential for overcoming these obstacles. Moreover, the use of blogs in educational contexts emerges as a double-edged sword; while they enhance technical skills and provide platforms for feedback, it is imperative for professors to streamline their use to alleviate the perceived burden on students. The necessity for specific tools and spaces to enhance the tutoring process, particularly for final projects, is highlighted. Structured support can significantly affect student outcomes and their overall success. Additionally, the prioritization of research over teaching within higher education contexts affects the engagement and satisfaction of non-research professors. A more balanced emphasis on both dimensions could enhance the educational experience for both faculty and students.

The findings also reveal that prior work experience enriches professors' Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK), thereby enhancing their overall teaching effectiveness. One of the main

contributions of this research is the incorporation of generative artificial intelligence (GAI) as an emerging dimension of Technological Knowledge (TK), capable of transforming the TPACK model into a dynamic and adaptive structure. In this regard, the study's objective was reformulated to explore how AI can act as a cognitive mediator in initial teacher training, facilitating the generation of contextualized pedagogical proposals through prompt design.

The results, synthesized in an analytical table, show that prompts designed from the interaction between TPACK knowledge types and contextual variables (such as attitude, experience, evaluation, resources, or teacher coordination) enable tools to generate responses aligned with real teaching practices. These responses not only reflect strategies already implemented by teachers but also amplify, systematize, and adapt them to new contexts. Within this framework, AI does not replace the teacher but enhances their capacity for planning, innovation, and pedagogical reflection. Its integration into initial teacher training allows for personalized learning paths, the generation of adapted teaching resources, and the promotion of active methodologies, thus contributing to the reduction of pedagogical frailty identified in previous studies (De Benito et al., 2017; Kinchin, Streatfield & Hay, 2010). The results suggest that AI can act as a cognitive mediator in the development of TPACK knowledge, offering adapted responses and promoting pedagogical reflection. Furthermore, the integration of AI in teacher training must be based on solid theoretical frameworks that guide its ethical, critical, and pedagogically meaningful application.

This work opens new lines of research on hybrid models such as TPACK-AI, the validation of prompts as training tools, and the exploration of AI-assisted learning environments that respect the disciplinary and contextual diversity of university professors. The combination of qualitative analysis, instructional design, and emerging technologies represents a promising path toward more innovative, reflective, and learner-centered teacher training. Finally, this work opens new lines of research around the development of hybrid models such as intelligent-TPACK, the validation of prompts as teacher training tools, and the exploration of AI-assisted learning environments that respect the disciplinary and contextual diversity of university faculty. The combination of qualitative analysis, instructional design, and emerging technologies represents a promising path toward more innovative, critical, and learner-centered teacher education.

4.1. Acknowledgments

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