

Co-design practices with artificial intelligence: an analysis of the developmental trajectories of pedagogical reasoning

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Abstract: This study investigates how 191 pre-service teachers develop their pedagogical reasoning while interacting with Artificial Intelligence (AI) in a co-design task. Using a mixed-methods design, a quantitative analysis (Model-Based Clustering) identified three distinct profiles: Diligent pragmatists (52.4%), Confident collaborators (20.4%), and Critical-reflective designers (27.2%). A qualitative textual analysis (TF-IDF) of the instructional designs confirmed that these profiles are defined not by technical skills, but by an emerging pedagogical stance toward technology, revealed by specific lexical patterns. The findings highlight the need for teacher education to shift from teaching how to “use” AI to educating on how to “think with” AI, fostering critical and reflective digital competence.

Keywords: Teacher training; Artificial Intelligence; Instructional design



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1. Introduction

To understand the advent of Generative AI and the new configuration of the educational landscape, it is necessary to define learning in terms of the interconnection and hybridization of bodies, algorithms, data, and environments. The educational context represents an ideal setting for observing competence as it develops. In light of the pervasiveness of digital media, it is essential to identify the necessary elements for an innovative, critical, and conscious pedagogical practice (Solís et al., 2023).

While opportunities for specific teacher training are increasing (e.g., the NRRP), a polarization between skepticism and uncritical trust is also emerging (Vinci & Berardi, 2025), which raises significant questions. In response to recent challenges, evidence invites reflection on the variables that influence the adoption of these tools and teachers’ attitudes towards them. Indeed, Cukurova, Miao, and Brooker (2023) have shown that the adoption of adaptive AI-based tools is conditioned not only by the quality of the tools themselves but also by factors such as trust, perceived support, workload, and ethical implications.

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The significant correlation between teachers' digital competence and their attitude towards technology (Galindo et al., 2024) underscores how a high level of preparation and digital management can effectively contribute to a more proactive stance on technological adoption. To understand the advent of Generative AI and the new configuration of the educational landscape, it is necessary to define learning in terms of the interconnection and hybridization of bodies, algorithms, data, and environments. The educational context represents an ideal setting for observing competence as it develops. In light of the pervasiveness of digital media, it is essential to identify the necessary elements for an innovative, critical, and conscious pedagogical practice (Solís et al., 2023).

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To delve deeper into the training process undertaken by pre-service teachers, with a particular focus on the design of hybrid instruction, this research is structured around three fundamental aspects: the modes of interaction with AI; its subsequent meaningful integration into practice; and the processes through which this competence, once acquired, is consolidated and qualified. Thus, moving beyond a mere evaluation of the advantages (Vivanet, 2014) and the critical issues related to the introduction of media, hybrid instruction is supported by national and international policies. These policies are aimed not only at methodological innovation but, above all, at developing digital competences that can enhance teacher professionalism. In line with the TPACK model (Mishra & Koehler, 2006), the recent Hybrid Education, Learning, and Assessment HELA framework (UNESCO, 2023), and DIGCOMP 2.0, teacher training is considered one of the most significant factors in developing students' key competences. For almost two decades, the integration of pedagogy, technology, and content (Mishra & Koehler, 2006) has extended beyond digital literacy to include a focus on learning environments and Open Educational Resources (2016-2019). This approach leverages sharing and collaboration but, above all, emphasizes reflective and design capabilities (Redecker, 2017).

The interaction between content, pedagogy, and technology extends towards a theory of AI-augmented instructional co-design (Vinci & Berardi, 2025). The importance of technological skills and knowledge, literacy, and competences for transversal lifelong learning translates into a professional capacity to interact with AI and to select and critically evaluate information (Ciasullo, 2023). Moreover, the skilled use of digital tools in schools (Perla, Agrati, Vinci, 2018) and teachers' intention to use AI (Perla & Agrati, 2024) optimize the efficiency and functionality of emerging technologies (Vuorikari, Kluzer & Punie, 2022; Redecker, 2017). From this perspective, UNESCO emphasizes the need for ethical use that is mindful of human rights and inclusion. The integration of AI, particularly in its generative capacity (Solís et al., 2023) and as a mediating tool, represents a concrete proposal for optimizing learning processes and outcomes (Miao & Cukurova, 2024), as well as for ensuring a qualified professional workforce attentive to innovation and its developments. In particular,

teacher training oriented towards the strategic use of Artificial Intelligence assumes a key role in instructional innovation. Training conceived in this way enhances teacher professionalism, as it enables the design and personalization of instructional approaches (Jamal, 2023). This research is specifically situated within the design of personalization and support for students with disabilities, aiming to develop professional competences that, through the integration of technology, can effectively respond to diverse educational needs.

2. Rationale and research questions

In the current academic discourse, research has predominantly focused on two main areas: the adoption of AI by teachers (Vivanet, 2014; Cukurova, et al., 2023) and the exploration of the technical potential of AI tools (Pedro, et al., 2019; Celik, et al., 2022). However, a crucial dimension remains underexplored: the genesis and development of teachers' competence in adopting hybrid practices. This paper aims to position itself within this strategic research gap by focusing on the processes through which pre-service teachers acquire and refine the capacity to interrogate Artificial Intelligence and, consequently, design personalized learning activities.

More precisely, the objective is to investigate the processes through which this capacity is formed and evolves in pre-service teachers during their first encounter with AI cognitive agents. The research seeks to move beyond a simple evaluation of final products to observe the evolution of pedagogical thinking. To this end, it adopts an innovative approach that interprets the artifacts of the dialogue between pre-service teachers and AI - namely the prompts, responses, and choices of critical revision - as digital traces of developing professional reasoning.

How do pre-service teachers, during a structured workshop experience, develop and modify their approaches to using AI for instructional design? The investigation is structured along three analytical dimensions:

The evolution of prompts: to analyze the trajectory of questions posed to the AI, mapping the growth of their pedagogical complexity and specificity as an indicator of maturing competence.

The exercise of critical judgment: to investigate the "delta," or the discrepancy between AI suggestions and the final artifact, and to make visible the tacit knowledge and values with which the pre-service teacher negotiates the technology's authority.

The emergence of design styles: to synthesize interaction patterns and construct a taxonomy of emerging approaches, thereby creating an interpretive framework for the different developmental trajectories of AI-augmented design competence.

3. Methods

The study involved a sample of 191 pre-service teachers enrolled in the second year of the Primary Education degree program at the University of Foggia. Data were collected during the participants' attendance at the Instructional Technology course workshop. The sample is predominantly female (97.4%, N=186). The participants' age is concentrated in the younger bracket, with a clear majority under 24 years old (59.7%, N=114) and over three-quarters of the sample under 30 (77%, N=147). Regarding educational qualifications, 58.6% (N=112) hold a high school diploma, while a considerable 41.4% (N=79) have already obtained an academic degree (bachelor's, master's, or doctorate), indicating heterogeneity in their prior educational paths. Consistent with their status as pre-service teachers, almost the entire sample is not currently working in the teaching profession (97.9%, N=187).

A significant finding is the high level of prior familiarity with Artificial Intelligence tools, reported by 93.7% (N=179) of participants, who used them mainly for

individual study (39.1%, N=70) or personal use (29.6%, N=53). At the end of an activity involving the co-design of a teaching unit with AI systems, an online questionnaire (CAWI - Computer-Assisted Web Interviewing) was administered, featuring open-ended, closed-ended, and Likert scale questions. For the present research, a targeted selection of items was analyzed in line with the research questions, focusing on the prompt sequences directed at the AI and the students' reflections on the interaction process.

To answer the research questions, an Explanatory Sequential Mixed Methods design (QUAN -> qual) was adopted, following the approach defined by Creswell and Plano Clark (2018). The quantitative phase (QUAN) aimed to segment the cohort into homogeneous profiles. To this end, three original quantitative variables were constructed to measure student behavior: the average length of mandatory prompts, to assess actual effort while excluding minimal responses; the number of minimal responses, to isolate disengaged behavior; and the presence of significant optional prompts, to measure the initiative to explore topics further. These three variables, along with three Likert scales concerning perceived utility, modification of the initial idea, and autonomy of judgment, were used to conduct a model-based clustering analysis with JASP software, set to identify three distinct clusters. The subsequent qualitative phase aimed to deeply understand and provide pedagogical substance to the profiles that emerged from the statistical analysis. To achieve this, a thematic analysis was conducted on the entire corpus of instructional designs developed by the participants, excluding only those that were clearly erroneous or irrelevant. The analysis therefore focused on the final artifact produced by the students, understood as a tangible trace of their professional reasoning.

The entire analysis process was conducted within the RStudio development environment, utilizing specific packages for qualitative text analysis. The objective was to identify the distinctive thematic, structural, and lexical patterns for each profile that emerged from the quantitative phase. Specifically, the analysis focused on exploring the following dimensions within the instructional design texts:

Pedagogical focus: to identify the prevailing educational themes and concepts in order to understand the priorities of each profile.

Design structure: to analyze the level of detail, coherence, and complexity with which the different phases of the Teaching Unit were articulated.

Professional language: to examine the vocabulary used to describe activities, objectives, and methodologies, as an indicator of the professional register adopted.

4. Results

The data analysis was structured using an Explanatory Sequential Mixed Methods design (QUAN -> qual), a strategic choice aimed not only at describing the behavior of pre-service teachers but also at understanding its underlying rationales. The objective was to move beyond an aggregated view of the sample to identify the existence of distinct interaction profiles with Artificial Intelligence, understood as genuine emerging pedagogical stances.

The initial quantitative phase, therefore, served an exploratory and taxonomic function. Through a Model-Based Clustering technique—an advanced statistical approach that identifies the most probable latent groupings within the data—the aim was to elicit an empirically grounded solution. The analysis, conducted with JASP software on the six key variables (three behavioral and three perceptual), yielded a three-cluster solution as the most stable and statistically robust. This partition was not imposed a priori but emerged from the data as the most effective way to describe the sample's variability. The result of this segmentation is a clear map of the different

interaction trajectories. A majority group was identified, the “Diligent pragmatists” profile (N=100, 52.4%), representing the modal approach, and two minority groups with more specific and polarized stances: the “Critical-reflective designers” (N=52, 27.2%) and the “Trusting collaborators” (N=39, 20.4%). These profiles, although statistically derived, proved to be immediately interpretable from a pedagogical standpoint, providing a solid foundation for the subsequent qualitative phase, which aimed to give them voice and substance through case study analysis.

The subsequent profiling phase outlined the distinctive characteristics of each group, as summarized in Table 1.

Table 1. Cluster profiles: means of behavioral and perceptual variables.

Profile	Diligent pragmatists	Trusting collaborators	Critical-reflective designers
AI Utility (1-10)	9.08	9.35	6.26
Idea Modification (1-10)	7.31	8.35	5.03
Judgment Autonomy (1-10)	7.54	5.59	8.51
Average Prompt Length (1-10)	148.4	68.9	20.3
No. of Minimal Responses	0.05	0.16	2.68
No. of Optional Prompts	0.82	1.48	0.17
Count (N)	115	37	39
Percentage (%)	60.2%	19.4%	20.4%

To add depth and validity to the interpretation of the three profiles, the qualitative phase analyzed the corpus of instructional designs. Through a TF-IDF (Term Frequency-Inverse Document Frequency) analysis, conducted in the RStudio environment, the most distinctive and characteristic lexical patterns for each cluster were identified, offering a qualitative confirmation of the stances identified quantitatively:

Critical-reflective designers: Their lexicon is the most abstract and meta-pedagogical. Keywords such as “objectives”, “group”, “competences”, “development”, and “reflection” dominate their vocabulary. This lexical choice shifts the focus from “what to do” (the activity) to “why do it” (its pedagogical architecture), confirming their strategic stance and full professional control.

Diligent pragmatists: Their language reflects a methodical and content-oriented approach. Terms like “reading”, “pupils”, “map”, “text”, and “words” are the most characteristic. Theirs is a “practitioner’s” lexicon, focused on classic curricular design and the logical organization of subject content, confirming their use of AI as an efficient structuring tool.

Trusting collaborators: Their vocabulary is dominated by terms that evoke the child’s concrete, narrative, and sensory experience. Words such as “story”, “colors”, “emotions”, “materials”, and “create” are the most distinctive. This lexical pattern confirms their inclination towards a “hands-on” pedagogy based on engagement and co-creation, where AI acts as a partner in a creative brainstorming session.

5. Discussion and conclusions

This research has investigated how pre-service teachers develop their approaches to instructional design by interacting with Artificial Intelligence, revealing the three distinct interaction profiles previously outlined. The most significant finding is that these profiles, Critical-reflective designers, Diligent pragmatists, and Trusting collaborators, do not primarily depend on technical skill. Instead, they derive from a nascent pedagogical stance towards technology, which is perceived as an agent with

which to negotiate autonomy, to which tasks can be delegated, or from which to elicit critical reflection. This highlights the need not only to provide digital tools and foster technical proficiency, but also to guide teachers toward a critical and ethical digital competence. At the necessary intersection of technological, pedagogical, and content knowledge, the research underscores the importance of mastering the dialogic relationship with Artificial Intelligence to leverage its design dynamism and, in some cases, its capacity for promoting reflectivity and reconsideration.

Consequently, integrating AI into teacher education is not a merely instrumental issue; it touches the core of professional identity. The implications for training are profound: it is necessary to move beyond training on specific software and instead foster pathways that promote awareness of one's own interaction style and support its critical evolution.

The study emphasizes the urgency of placing pedagogical reflection at the center of teacher training. The goal is not just to teach how to “use” AI, but how to think critically with AI, in order to develop the professional wisdom that constitutes the irreplaceable value of pedagogical practice.

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