Prompting the future: educator competencies and case-based innovation for GenAI in higher education

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Abstract

The integration of Generative Artificial Intelligence (GenAI) in higher education is transforming teaching and learning. This paper explores the implications of GenAI, focusing on prompt-based learning and prompt engineering. When used responsibly, GenAI can promote metacognition, student autonomy and customise learning support. We present three case studies from the University of Genoa: a gamified digital literacy course in the social sciences; a human-centred, problem-solving course in the digital humanities; and an engineering course on embedded systems design. These cases demonstrate the effectiveness of structured prompting techniques using tools such as ChatGPT and GitHub Copilot, and exemplify varied levels of AI integration. Outcomes include improved student engagement, autonomy and advanced technical production. The paper emphasises the necessity of structured training and certification for educators, including the EPICT Conversational AI syllabus, which aligns with the DigCompEdu and DigComp European frameworks. We advocate the adoption of coherent policies and the conduct of longitudinal empirical research to guide the ethical and effective integration of GenAI in educational settings, as well as the development of scalable pedagogical models.

Keywords

Prompt-Based Learning, Generative AI, AI Literacy, Higher Education Innovation, Human-AI Collaboration, Prompt Engineering, Digital Competence Frameworks,

1. Introduction

The rapid advancement of Generative Artificial Intelligence (GenAI) is transforming higher education by offering new ways to personalise instruction and enhance metacognitive engagement. Tools such as ChatGPT [1], Claude [2] and Bard [3], provide round-the-clock adaptive support, encouraging student autonomy and cultivating critical and reflective thinking [4, 5].

In this evolving context, universities are tasked with equipping educators with technological proficiency, as well as sophisticated pedagogical and ethical competencies, in order to enable them to effectively integrate AI into their teaching practices [6, 7]. One pivotal emerging role is that of the Conversational AI Educator: a professional who can balance technical skills with pedagogical insight and ethical awareness [6]. The emergence of this new professional role highlights the need for formal certification processes, such as the Conversational AI syllabus developed at the University of Genoa. This syllabus is aligned with the European DigCompEdu and DigComp 2.2 frameworks, ensuring comprehensive competence development and international recognition [8, 9]. The educational effectiveness of integrating AI largely depends on educators' ability to engage in prompt engineering — a critical skill for leveraging AI's full potential by providing generative systems with precise, contextually relevant prompts that drive accurate, pedagogically valuable responses [10]. Prompt-based learning (PBL) is an educational methodology that has shown significant promise in fostering higher-order cognitive skills and improving learner autonomy by promoting active and reflective interactions with AI [11, 12].

ITAL-IA 2025, V Convegno Nazionale CINI sull'Intelligenza Artificiale, June 23–24, 2025, Trieste, Italy

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Consequently, educators require structured, recognised training to master prompt engineering and utilise it effectively as a robust instructional strategy within diverse educational scenarios.

At a broader European level, the European Commission's Joint Research Centre is scheduled to finalise the revision of DigComp framework by 2025: DigComp 3.0 [13]. This update explicitly acknowledges the widespread impact of AI on digital competencies and addresses current requirements such as AI literacy, cybersecurity, and adherence to evolving regulations like the *EU AI Act* [14]. The update is expected to reinforce the critical intersection between technological innovation and ethical considerations in education.

This paper addresses these transformative aspects by presenting a structured analysis based on three case studies from the University of Genoa in Italy. They illustrate the practical application of AI-enhanced methodologies in real educational settings. The studies specifically explore AI-assisted learning in a foundational digital literacy course for social sciences undergraduates; AI-driven, complex problem-solving strategies in a Digital Humanities master's programme; and AI-facilitated system design within an embedded systems master's curriculum. Together, these cases highlight the tangible benefits and critical challenges of integrating GenAI into higher education, emphasising the importance of responsible and ethical adoption.

2. The transformative power of GenAI and Prompt-Based Learning

GenAI is redefining educational experiences by creating dynamic, personalised, and adaptive learning environments. Unlike traditional instruction, GenAI provides real-time feedback and tailored content, significantly enhancing student engagement, autonomy, and performance [15]. These technologies have proven effective in increasing motivation, alleviating cognitive load, and fostering deeper learning through personalised strategies [4, 16].

In addition to improving learning outcomes, GenAI tools offer continuous support that bridges formal instruction and independent study. This constant academic companionship is particularly valuable for students from underrepresented or disadvantaged backgrounds, promoting equity and inclusion in education [17]. Studies confirm that AI-driven tutoring systems can help close achievement gaps by delivering personalised, on-demand assistance that traditional teaching often cannot provide [18].

However, integrating GenAI also introduces new challenges. Ethical concerns such as data privacy, algorithmic bias, and the potential loss of human interaction must be addressed [19, 20]. Overreliance on AI systems may undermine students' capacity for independent thinking and collaborative learning [21]. Therefore, maintaining transparency and accountability is critical to sustaining trust and educational integrity.

This paradigm shift calls for a redefinition of the educator's role: the emerging profile of the *Conversational AI Educator* exemplifies this transition, a professional capable of orchestrating ethical, effective, and pedagogically meaningful human–AI interactions [6]. Educators must be equipped with new skills to integrate GenAI as a collaborative teaching partner while preserving human-centered values.

Central to this integration is the practice of prompt engineering, the ability to craft precise, context-aware prompts that guide AI systems effectively [10]. This skill enhances instructional design, allowing AI to deliver accurate, relevant responses while empowering learners to think critically and solve problems through structured, iterative interaction.

PBL builds on this foundation by emphasising student agency and metacognitive development. Students iteratively refine prompts based on AI feedback, improving their ability to ask meaningful questions, identify knowledge gaps, and evaluate responses critically. Research shows that PBL significantly increases learner motivation, autonomy, and engagement, especially in problem-solving contexts [4, 6].

To institutionalise these practices, educators require structured training and recognition. Programmes like the Conversational AI syllabus developed at the University of Genoa offer a clear certification path, aligning technical skills with pedagogical and ethical competencies [6]. These initiatives help ensure consistent educational quality and responsible AI integration in teaching.

3. Frameworks, certification, and policy alignment for AI competence in education

The growing integration of GenAI in education necessitates structured certification frameworks to ensure educators are equipped with the skills required to implement AI effectively and ethically. Certification programmes offer clear benchmarks that support professional growth and elevate instructional quality through recognised standards [6].

A notable example is the EPICT Conversational AI syllabus developed by the University of Genoa, which defines three levels of certification: Integrator, Expert, and Leader. These levels correspond to increasing proficiency in AI integration—from foundational classroom application to advanced design of AI-based educational experiences, and ultimately to institutional leadership in AI innovation [6].

These initiatives align with European frameworks such as DigCompEdu and the forthcoming DigComp 3.0. While DigCompEdu outlines digital competence for educators with an emphasis on innovative and responsible technology use [8], DigComp 3.0 is expected to incorporate AI literacy, cybersecurity, and ethics in response to societal and regulatory demands [9, 13]. The revised framework will support educators in navigating AI systems critically and using them in a way that reflects transparency, fairness, and ethical standards.

Such transformation is unfolding within a broader European policy landscape, including the *Digital Education Action Plan* and UNESCO guidelines on AI in education. Events such as the Digital Learning Week 2025 further reinforce the international momentum towards comprehensive AI literacy. These frameworks advocate critical thinking, algorithmic transparency, and ethical responsibility as foundations for educational innovation [5, 22].

Universities are central actors in this process, serving as training hubs, research centres, and agents of policy implementation. By offering certification pathways and embedding AI-related competencies into their curricula, universities help standardise the responsible use of GenAI across the educational system. They also ensure alignment with the EU AI Act and similar regulations, building a future-ready educational workforce capable of adapting to rapid digital transformation [7].

4. Case-Based Integration of Generative AI Across Educational Profiles

GenAI has been implemented in diverse university contexts, demonstrating its versatility and scalability across different academic levels and disciplinary domains. The following case studies from the University of Genoa illustrate how GenAI can support foundational digital literacy, interdisciplinary problem-solving, and advanced system design through prompt-based methodologies and AI-assisted tools.

Generative AI for Digital Literacy (Undergraduate Course in Social Sciences). The Web Dev Challenge was implemented in an undergraduate digital literacy course to enhance foundational programming skills through a sequence of AI-supported weekly tasks. Students used GenAI to write prompts, interpret feedback, and iteratively refine code. The integration of gamification strategies fostered motivation and engagement. Feedback indicated improvements in confidence, programming fluency, and prompt engineering. A key component was the "Daniele Virtual Tutor", an AI assistant offering personalised, real-time support. Despite its limitations compared to human tutors, students highlighted its usefulness in facilitating learning and overcoming the challenges of complex tasks [23].

Generative AI in Problem-Solving (Master's Course in Digital Humanities). A human-centred, problem-solving framework was applied in a Digital Humanities course using GenAI, Python programming, and object-oriented modelling. Students with limited technical backgrounds developed executable code from scholarly questions by iteratively refining prompts. This process strengthened critical thinking, computational reasoning, and interdisciplinary synthesis. The model proved transferable beyond technical fields, showing potential for widespread adoption in contexts requiring conceptual problem-solving and collaborative inquiry.

Generative AI in Embedded Systems Design (Master's Course in Mechatronic Engineering). The "Software Architecture for Embedded Systems" course integrated GenAI tools such as ChatGPT

and GitHub Copilot to accelerate design and development in complex technical projects. Students used Prompt-Based Learning to prototype, test, and document robotic systems with SLAM functionalities. AI tools supported code generation, debugging, and UML modelling. Students maintained decision-making authority while using AI for augmentation, demonstrating improved design quality, autonomy, and reflective thinking in technical problem-solving [24].

Comparative Analysis. Table 1 summarises the three case studies, comparing their application domains, levels of AI integration, prompt types, developed competencies, and key outcomes.

Aspect	Web Dev Challenge	Problem-Solving	Embedded Systems
Application Domain	Social	Humanities	Technical
Level of AI Integration	Moderate (supportive tool, gamified)	High (integral to problem-solving and coding)	High (integral to system design and technical development)
Prompt Types Utilized	Educational prompts, iterative feedback, structured prompts	Iterative prompts, precise coding instructions, interdisciplinary tasks	Technical prompts, detailed coding, debugging, UML diagrams
Competencies Developed	Programming skills, autonomous learning, prompt engineering	Computational thinking, critical thinking, interdisciplinary insights	Technical expertise, critical thinking, system design, prompt engineering
Main Outcomes	High motivation, increased autonomy, foundational programming skills	Enhanced problem-solving capabilities, interdisciplinary integration, improved AI literacy	Advanced technical solutions, rapid prototyping, high-quality project outcomes

Table 1: Comparative analysis of AI-enhanced educational case studies

This comparative analysis demonstrates the significant enhancement of educational outcomes across diverse academic contexts through the implementation of GenAI via methodologies such as prompt engineering and prompt-based learning. The analysis reveals the distinct strengths of each approach, ranging from the development of foundational technical literacy in the social sciences to the enhancement of complex interdisciplinary problem-solving in digital humanities and advanced technical development in mechatronics. The effectiveness and versatility of GenAI in these different educational scenarios suggests its broad applicability and potential for adoption in higher education curricula.

The analysis also invites a broader metacognitive reflection: the adoption of GenAI does not only reshape *what* is taught—such as coding, problem-solving, or data analysis—but fundamentally transforms *how* students learn. PBL fosters dialogic interaction, iterative exploration, and reflective refinement, enabling learners to become active co-constructors of knowledge rather than passive recipients. In this light, GenAI can be viewed as a catalyst for rethinking instructional design towards more adaptive, student-centered paradigms, where metacognitive awareness and formative feedback loops are embedded in the learning process.

Evaluation Metrics. Across the three case studies, student engagement was assessed through weekly activity logs and self-reported reflections. Autonomy was evaluated based on the frequency and quality of independent prompt refinements without human assistance. Technical outcomes (e.g., code quality, solution completeness) were rated using rubrics aligned with course objectives. These instruments support internal consistency and reproducibility across contexts. Details are available in the referenced publications in Section 4.

5. Ethics, Responsible Integration, and Future Directions for Generative AI in Higher Education

The integration of GenAI into university teaching offers transformative potential across disciplines. From digital literacy in the social sciences to problem-solving in the humanities and system design in engineering, each case illustrates how GenAI can enhance learning through context-sensitive methodologies.

A key insight is the versatility of PBL and prompt engineering, which foster higher-order reasoning, autonomy, and iterative refinement. Students learn to formulate and adjust prompts, assess AI outputs, and improve their approaches—developing skills increasingly relevant across domains.

The pedagogical strategies observed form a continuum of AI integration—from supportive tools in foundational courses to collaborative design frameworks in advanced settings. This supports the generalisation of prompt-based models as adaptable and scalable frameworks across curricula.

However, GenAI integration raises ethical and regulatory concerns. Risks such as hallucinations and algorithmic bias can undermine equity and trust. Institutions must adopt robust verification, promote AI literacy, and embed bias mitigation in teaching protocols [5, 20, 25].

Transparency and accountability are essential. Universities should align with evolving regulations, including the EU AI Act, by integrating legal and ethical training into educator development [22, 7]. This prepares educators to apply GenAI in pedagogically sound and compliant ways.

Scalability considerations. Adoption of GenAI-enhanced practices does not require advanced infrastructure: mainstream tools like ChatGPT or GitHub Copilot, combined with basic digital access and targeted training (e.g., the EPICT syllabus), allow for flexible deployment across institutions with varied resources.

Future directions. To evaluate long-term impacts, a longitudinal tracking initiative has been launched to monitor the evolution of student autonomy, AI literacy, and reflective competence. Further cross-disciplinary experimentation will help refine these emerging pedagogies and inform digital and civic competence frameworks.

These experiences highlight the central role of educator readiness—not only in technical skills, but also in guiding ethical AI-human interaction. Prompt engineering emerges as both a practical and metacognitive strategy, empowering learners to interrogate and refine their thinking.

Finally, institutional support—through structured training, certification pathways, and alignment with digital competence frameworks—is key to sustainable innovation. When used ethically and creatively, GenAI can enrich education, enhance learner autonomy, and deepen cognitive engagement without replacing the human dimension.

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT, Gemini, and Grammarly in order to: Grammar and spelling check, Paraphrase and reword. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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