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Prompt Engineering as a Digital Literacy Skill: A Conceptual Framework for Effective Human–AI Collaboration

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Abstract

The rapid adoption of generative artificial intelligence (AI) tools has transformed the way individuals interact with digital technologies across educational, professional, and research contexts. Despite the growing reliance on AI systems, many users lack the competencies required to formulate effective prompts, evaluate AI-generated outputs, and engage in responsible human–AI collaboration. Existing digital literacy frameworks primarily emphasize information access, communication, and technology use, while providing limited attention to prompt engineering as a distinct digital competency. This research introduces the conceptual model, the PIERCE Framework, which places prompt engineering as a crucial digital literacy skill in the era of generative AI. The framework was conceptualized by analyzing the latest literature on digital literacy, AI literacy, human–AI interaction, and prompt engineering. The proposed framework is divided into six interrelated components: Prompt Intent Formulation, Intelligent Prompt Design, Engagement with AI, Response Evaluation, Continuous Refinement, and Ethical Application. Together, these components provide a structured pathway for effective human–AI collaboration. The framework contributes to the growing discourse on AI literacy by offering a comprehensive perspective on the competencies required for productive and responsible AI use. The findings highlight the importance of integrating prompt engineering into future digital literacy initiatives, educational programs, and professional development practices.

Keywords: Prompt Engineering A, Digital Literacy B, AI Literacy C, Human–AI Collaboration D, Generative Artificial Intelligence E

1. INTRODUCTION

The emergence of generative artificial intelligence (AI) has significantly transformed the way people interact with digital technologies. Unlike conventional digital tools that primarily support information retrieval and communication, generative AI systems are capable of producing human-like responses, generating content, assisting decision-making, and supporting problem-solving activities across various domains. As a result, AI-powered applications have become increasingly integrated into educational environments, professional workplaces, research activities, and everyday digital interactions [1], [2], [3].

The use of generative AI tools has opened up new avenues for enhancing productivity, creativity, and knowledge acquisition. Students increasingly utilize AI systems to support learning activities, researchers employ AI-assisted tools for information synthesis and content development, and professionals leverage AI technologies to enhance efficiency in diverse

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workplace tasks. The growing accessibility of large language models has accelerated this trend, allowing individuals with varying levels of technical expertise to interact with sophisticated AI systems through natural language communication [4], [5], [6].

However, the effectiveness of human–AI interaction is not determined solely by the capabilities of AI systems. The quality of AI-generated outputs is often influenced by the quality of the instructions provided by users. Poorly formulated prompts may produce inaccurate, incomplete, or irrelevant responses, whereas carefully designed prompts can significantly improve the relevance, clarity, and usefulness of AI-generated content. As a result, effective communication with AI systems has become a growing skill in the digital age [7], [8].

This growing importance has contributed to the emergence of prompt engineering as a critical practice within the field of human–AI interaction. Prompt engineering refers to the process of designing, structuring, refining, and optimizing instructions to achieve desired outputs from AI systems. Although prompt engineering initially gained attention as a technical skill among AI practitioners and developers, its relevance has expanded far beyond technical communities. Today, individuals from diverse educational and professional backgrounds are required to develop effective prompting strategies in order to maximize the benefits of AI-assisted technologies [9], [10], [11].

Existing digital literacy frameworks have traditionally focused on competencies such as information access, communication, content creation, digital safety, and problem-solving in technology-rich environments. These frameworks have been important in shaping the education and policy landscape for preparing people for an increasingly digital society. More recently, the emergence of artificial intelligence has stimulated the development of AI literacy frameworks that emphasize understanding AI concepts, evaluating AI-generated information, recognizing ethical implications, and promoting responsible AI use. These developments are indicative of the need for digital literacy to keep pace with technological advancements [12], [13], [14].

Despite these efforts, there is still a gap in the current literature. While numerous studies acknowledge the importance of AI literacy and responsible AI use, relatively limited attention has been given to prompt engineering as a distinct digital competency. Existing discussions frequently focus on the technical aspects of prompting or provide practical guidelines for interacting with AI systems. Yet, there are still no comprehensive frameworks that conceptualize prompt engineering as a key literacy skill that can be used to facilitate effective, critical, and responsible human–AI interaction in various contexts [15], [16].

Moreover, the growing availability of generative AI tools has broadened the user base of AI beyond the technical community. AI systems are now commonplace in the lives of students, teachers, researchers, professionals, and the general public. This has led to a growing need for clear goal setting, crafting of effective prompts, critical analysis of AI-generated content, iterative refinement of interactions, and responsible use of AI. However, these skills are usually talked about in isolation and not as part of a coherent framework [17], [18].

To fill this void, this study introduces the PIERCE Framework, a conceptual framework that places prompt engineering as a fundamental digital literacy skill in the age of generative AI. The framework is divided into six interrelated dimensions: Prompt Intent Formulation, Intelligent Prompt Design, Engagement with AI, Response Evaluation, Continuous Refinement, and Ethical Application. Collectively, these dimensions provide a structured pathway for enhancing the quality of human–AI interaction while promoting responsible and effective AI use.

The objective of this study is to develop and present a conceptual framework that explains how prompt engineering can be understood and applied as a digital literacy skill. By integrating concepts from digital literacy, AI literacy, human–AI interaction, and prompt engineering, this study contributes to the growing discourse on AI-enabled competencies and provides a foundation for future research, educational initiatives, and professional development

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programs related to effective human–AI collaboration.

2. METHODS

2.1 Research Design

This study employed a conceptual research design to develop a framework that positions prompt engineering as a digital literacy competency for effective human–AI collaboration. Unlike empirical studies that rely on surveys, experiments, or observational data, conceptual research focuses on the integration, interpretation, and synthesis of existing knowledge to generate new theoretical perspectives and frameworks. This was deemed suitable as the study's main goal was not to quantify a phenomenon but to develop a conceptual framework for prompt engineering in the context of digital literacy and AI-powered interaction [19], [20].

The conceptual approach enables researchers to examine relationships among existing concepts, identify emerging trends, and propose theoretical models that contribute to academic discourse. Given the rapid development of generative artificial intelligence technologies and the growing importance of effective human–AI interaction, a conceptual framework was considered suitable for organizing existing knowledge and identifying key competencies required for responsible and productive AI use [21].

2.2 Literature Review and Concept Identification

The development of the proposed framework was informed by a comprehensive review of literature related to digital literacy, AI literacy, prompt engineering, human–AI interaction, and generative artificial intelligence. Relevant journal articles, conference proceedings, scholarly reports, and conceptual studies were examined to identify recurring themes, competencies, challenges, and recommendations associated with effective interaction with AI systems [22], [23].

Particular attention was given to recent studies discussing the evolution of digital literacy in the era of artificial intelligence. The review focused on identifying competencies frequently highlighted across the literature, including communication with AI systems, critical evaluation of AI-generated outputs, iterative interaction processes, ethical considerations, and responsible technology use. These concepts served as the foundation for the development of the proposed framework [24], [25].

The literature review was done in an iterative manner. Concepts identified in one study were compared with findings from other studies to determine similarities, differences, and recurring patterns. This process helped establish a comprehensive understanding of the competencies necessary for effective prompt engineering and AI-assisted problem solving [26].

2.2.1 Literature Search Strategy

The conceptual framework was developed through a structured literature search designed to identify relevant studies on digital literacy, artificial intelligence literacy, prompt engineering, human–AI interaction, and generative artificial intelligence. Literature retrieval was conducted using internationally recognized scholarly databases, including Scopus, Web of Science, IEEE Xplore, ACM Digital Library, ScienceDirect, SpringerLink, and Google Scholar. The choice of these databases was made because they offer wide coverage of peer-reviewed publications in computer science, educational technology, information systems and artificial intelligence [22], [23].

Literature search was conducted using combinations of keywords and Boolean operators to maximize the retrieval of relevant publications. Common search terms were "prompt

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engineering" AND "digital literacy", "AI literacy", "generative artificial intelligence", "human–AI collaboration", "large language models", "artificial intelligence in education", and "digital competence framework". Further backward and forward citation tracking was conducted to find influential studies that were relevant to the conceptualization of the proposed framework [24], [25].

Inclusion and exclusion criteria were used to ensure the reviewed literature was relevant and of high quality. The inclusion criteria comprised peer-reviewed journal articles, conference proceedings, international organizational reports, and conceptual or review studies published primarily between 2023 and 2025, with several foundational references retained where necessary to support established theoretical concepts. Publications were required to address one or more of the study's core themes, including digital literacy, AI literacy, prompt engineering, human–AI interaction, or responsible AI use. Publications that were not sufficiently academically rigorous, not directly related to the research objectives, or that duplicated previously identified concepts were not reviewed [32], [34].

The selected studies were subsequently analyzed through an iterative conceptual synthesis process. Concepts extracted from the literature were systematically compared, categorized, and integrated to identify recurring competencies, conceptual relationships, and emerging themes. The result of this analytical process was the identification of six interrelated dimensions that make up the proposed PIERCE Framework [26], [27].

2.3 Framework Development Process

After the literature review, the concepts identified were then put through a process of conceptual synthesis. Similar competencies were grouped into broader categories, while overlapping concepts were integrated to reduce redundancy and improve conceptual clarity. In this iterative analysis, six core dimensions consistently emerged as fundamental elements of effective prompt engineering and human–AI collaboration [27].

This framework is called the PIERCE Framework, and it is composed of six interconnected dimensions: Prompt Intent Formulation, Intelligent Prompt Design, Engagement with AI, Response Evaluation, Continuous Refinement, and Ethical Application. These dimensions together embody the cognitive, technical, evaluative, and ethical skills needed for successful interaction with generative AI systems.

The framework was designed to provide a structured pathway that guides users from the initial identification of objectives through the formulation of prompts, interaction with AI systems, evaluation of generated outputs, refinement of prompts, and responsible application of AI-assisted outcomes. By integrating these dimensions into a unified model, the PIERCE Framework offers a comprehensive perspective on prompt engineering as an emerging digital literacy competency in the age of generative artificial intelligence.

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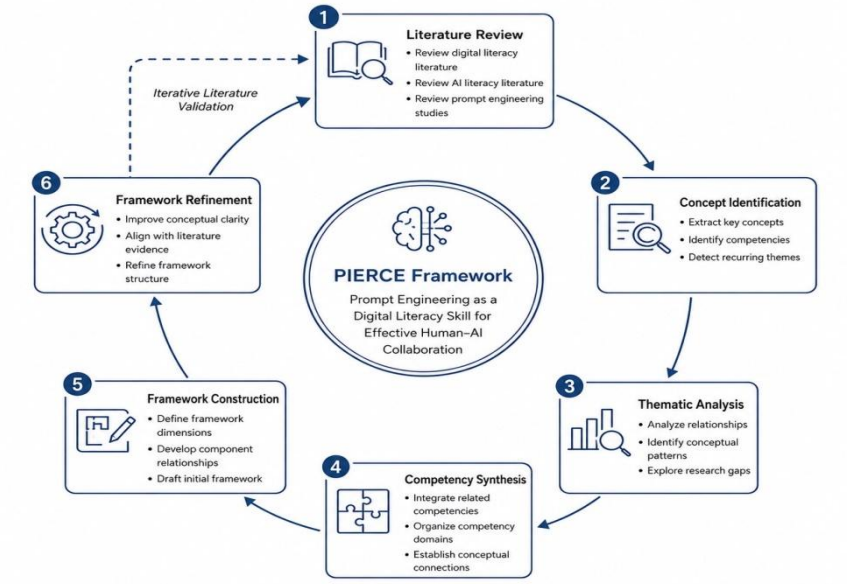

Figure 1. Conceptual Framework Development Process for the Development of the PIERCE Framework

3. RESULTS AND DISCUSSION

3.1 The Proposed PIERCE Framework

The primary outcome of this study is the development of the PIERCE Framework, a conceptual model that positions prompt engineering as a digital literacy skill for effective human–AI collaboration. The framework was developed through the synthesis of concepts derived from digital literacy, AI literacy, prompt engineering, and human–AI interaction literature. The resulting model offers a structured view of the skills needed for people to effectively, critically, and responsibly interact with generative AI systems [28], [29].

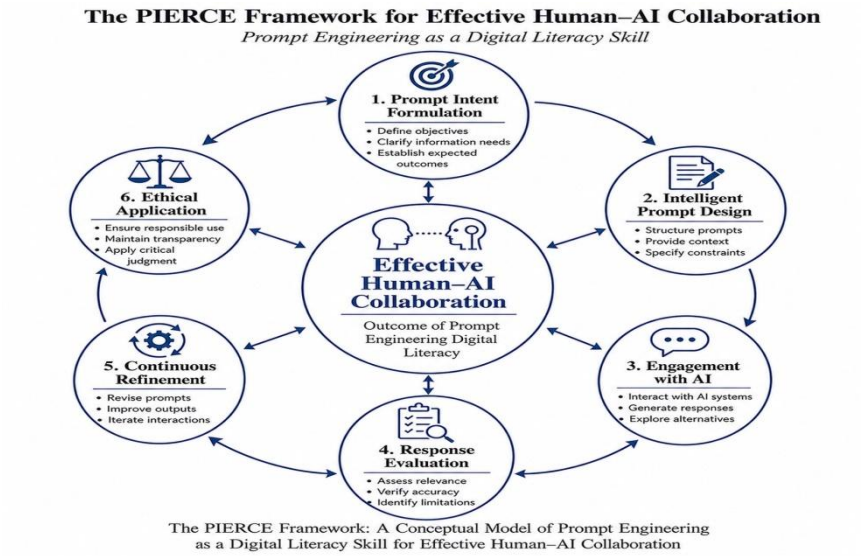

Figure 2. The PIERCE Framework for Effective Human–AI Collaboration

As illustrated in Figure 2, the PIERCE Framework consists of six interconnected dimensions: Prompt Intent Formulation, Intelligent Prompt Design, Engagement with AI,

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Response Evaluation, Continuous Refinement, and Ethical Application. Together, these dimensions embody the cognitive, technical, evaluative, and ethical skills required for effective collaboration between humans and AI. The proposed framework is not a linear process of prompt creation, but rather a continuous and iterative process where users interact with AI systems, assess the outputs, adjust their interactions, and use the AI-generated information responsibly [30].

The framework also highlights that the effectiveness of human–AI collaboration depends on more than just the technical performance of AI systems. Instead, the key to achieving positive results lies in the user's capacity to set clear goals, interact with AI systems, evaluate the output critically, and uphold ethical standards throughout the process. Consequently, prompt engineering is positioned as an emerging digital literacy competency that extends beyond technical expertise and becomes relevant to a broad range of users, including students, educators, researchers, professionals, and policymakers.

Table 1. Core Components of the PIERCE Framework

Dimension	Description	Key Functions
Prompt Intent Formulation	Establishing clear objectives and expected outcomes before interacting with AI systems.	Goal definition, information needs identification, outcome specification
Intelligent Prompt Design	Structuring prompts to maximize response quality and relevance.	Context provision, instruction formulation, constraint specification
Engagement with AI	Active interaction with AI systems to generate and explore responses.	Communication, response generation, alternative exploration
Response Evaluation	Assessing the quality, relevance, accuracy, and limitations of AI-generated outputs.	Verification, critical assessment, quality control
Continuous Refinement	Improving prompts and interactions through iterative modification and feedback.	Prompt revision, output improvement, iterative learning
Ethical Application	Ensuring responsible, transparent, and accountable use of AI-generated content.	Ethical judgment, transparency, responsible use

3.1.1 Prompt Intent Formulation

Prompt Intent Formulation represents the foundational dimension of the PIERCE Framework. Effective interaction with AI systems begins with the user's ability to clearly define objectives, identify information needs, and establish desired outcomes before constructing prompts. Without a clear understanding of the intended purpose of the interaction, users may generate vague instructions that result in incomplete or irrelevant responses. Therefore, this dimension emphasizes goal-oriented thinking as a prerequisite for productive human–AI collaboration.

The significance of Prompt Intent Formulation goes beyond the construction of the prompt. It encourages users to engage in critical reflection regarding the purpose of AI use and the expected value of AI-generated outputs. By clarifying objectives prior to interaction, users can improve the precision, relevance, and effectiveness of communication with AI systems.

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3.1.2 Intelligent Prompt Design

Intelligent Prompt Design refers to the ability to structure prompts in a manner that facilitates meaningful and contextually appropriate AI responses. This dimension focuses on how users communicate instructions, provide contextual information, specify constraints, and define desired output formats. Good prompt design can help AI systems produce responses that are more likely to meet user expectations and desired outcomes.

In the PIERCE Framework, Intelligent Prompt Design acts as the link between human intent and AI interpretation. Effective prompts minimize ambiguity, boost the quality of responses, and make human-AI interactions more efficient. With the growing sophistication of generative AI technologies, the skill of creating effective prompts is becoming a key digital literacy competency [31].

3.1.3 Engagement with AI

Engagement with AI refers to the active interaction between users and artificial intelligence systems during the prompt-response process. Rather than functioning as passive recipients of AI-generated information, users participate in a dynamic exchange in which prompts are submitted, responses are analyzed, and additional inquiries may be generated to achieve desired outcomes. This dimension recognizes that effective human–AI collaboration is inherently interactive and requires continuous communication between the user and the AI system.

The significance of Engagement with AI lies in its emphasis on exploration and adaptability. AI systems can offer several different viewpoints, options, and degrees of detail. Consequently, users must develop the ability to navigate these responses, identify valuable information, and leverage AI capabilities strategically to support learning, decision-making, creativity, and problem-solving activities.

3.1.4 Response Evaluation

Response Evaluation represents the critical assessment stage of the framework. While generative AI systems can produce sophisticated and convincing outputs, the quality, accuracy, and reliability of these outputs cannot be assumed automatically. It is therefore the user's responsibility to check the relevance, correctness, completeness, consistency, and possible bias of the information generated by AI [32], [33].

This dimension highlights the importance of critical thinking within AI-assisted environments. Effective users are not just taking information at face value from AI; they are checking the facts, cross-referencing information, and evaluating whether the AI-generated content is relevant to the goals. Through systematic evaluation, users can reduce the risks associated with misinformation, inaccuracies, and inappropriate AI outputs.

3.1.5 Continuous Refinement

Continuous Refinement emphasizes the iterative nature of prompt engineering. AI interactions are not typically a one-way street. Rather, users often edit prompts, add context, clarify instructions, and tweak constraints to enhance the quality of the output. This cycle allows users to gradually get closer to the right and relevant answers.

In the PIERCE Framework, Continuous Refinement is considered a key competency as it fosters learning, adaptability, and problem-solving. As users interact with and adjust the AI systems, they become more familiar with how the systems interpret their instructions and respond. Consequently, they are better equipped to leverage AI tools to tackle increasingly complex tasks and challenges.

3.1.6 Ethical Application

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Ethical Application is the last pillar of the PIERCE Framework and a principle to follow when using AI responsibly. The growing use of generative AI in education, work, and society has raised concerns about transparency, accountability, academic integrity, privacy, bias, and misinformation [34], [35].

This dimension emphasizes that users remain responsible for the outcomes of AI-assisted activities. Ethical Application requires individuals to exercise critical judgment, disclose appropriate AI usage when necessary, respect intellectual property considerations, and ensure that AI-generated content is applied responsibly. By integrating ethical considerations into the framework, the PIERCE Framework reinforces the principle that effective human–AI collaboration should not only be productive but also responsible, trustworthy, and aligned with broader societal values.

3.2 Comparison with Existing Digital Literacy Frameworks

The rapid growth of generative artificial intelligence has prompted scholars and educators to reconsider the competencies required for effective participation in digital environments. The traditional digital literacy frameworks have been centered on information access, communication, content production, digital safety, and problem-solving. These skills are still relevant, but with the growing prevalence of AI systems in daily life, new interaction patterns have emerged that go beyond the scope of traditional digital literacy frameworks [36], [37].

A useful point of comparison is the European Digital Competence Framework for Citizens (DigComp 2.2), which provides a comprehensive structure for digital competence by emphasizing information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Likewise, recent AI literacy frameworks focus on developing users' understanding of AI concepts, critical evaluation of AI-generated outputs, and responsible AI use. These frameworks offer valuable building blocks for digital and AI skills, but do not explicitly define prompt engineering as a competency that requires deliberate prompt creation, incremental improvement, and ongoing human-AI interaction. The proposed PIERCE Framework extends these perspectives by positioning prompt engineering as a multidimensional digital literacy competency that supports effective, critical, and responsible interaction with generative AI systems [14], [29].

Similarly, emerging AI literacy frameworks have emphasized the importance of understanding AI concepts, recognizing the capabilities and limitations of AI systems, evaluating AI-generated information, and promoting responsible AI use. These frameworks have made a significant contribution to the understanding of human interaction with intelligent technologies. However, they often provide limited attention to the practical competencies required for designing effective prompts and managing iterative interactions with generative AI systems [38].

The PIERCE Framework addresses this limitation by explicitly positioning prompt engineering as a digital literacy competency. The framework does not view prompting as a technical skill, but rather as a multi-dimensional process that includes goal setting, prompt design, interaction, prompt evaluation, prompt refinement, and ethical prompt use. This view extends the current concept of digital literacy to include skills that are increasingly relevant in an AI-mediated world.

Furthermore, the framework emphasizes the iterative and collaborative nature of human–AI interaction. The PIERCE Framework acknowledges that users actively shape the outcomes of AI systems through ongoing interaction and refinement, whereas traditional digital literacy frameworks emphasize information consumption and communication. This distinction highlights the evolving role of digital literacy in the age of generative artificial intelligence.

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Table 2. Comparison Between Traditional Digital Literacy and the PIERCE Framework

Aspect	Traditional Digital Literacy	PIERCE Framework
Primary Focus	Information access and communication	Effective human-AI collaboration
Information Interaction	Use of digital tools	Interaction with generative AI systems
Prompt Design	Not explicitly addressed	Core competency
Response Evaluation	General information evaluation	AI-specific output evaluation
Iterative Interaction	Limited emphasis	Continuous refinement process
Ethical Considerations	Digital citizenship and safety	Responsible AI use and accountability
Outcome	Digital participation	Effective and responsible AI-assisted performance

3.3 Practical implications of the PIERCE framework

The PIERCE Framework offers several practical implications for educational institutions, researchers, professionals, and policymakers seeking to promote effective and responsible AI use. With the increasing use of generative AI in academic, professional, and daily settings, there is a growing demand for structured competencies that allow people to interact with AI systems effectively. The framework provides a comprehensive approach for addressing this need by positioning prompt engineering as a digital literacy competency rather than merely a technical skill.

In educational contexts, the framework can support curriculum development aimed at preparing students for AI-enabled learning environments. Educational institutions can incorporate the six dimensions of the framework into digital literacy and AI literacy programs to help students develop competencies related to prompt design, critical evaluation, iterative learning, and ethical AI use. Such integration may contribute to more effective learning experiences and improve students' ability to utilize AI tools responsibly and productively [39].

For researchers, the framework provides a conceptual foundation for investigating prompt engineering practices and human–AI interaction. Future studies may utilize the framework to examine relationships among the six dimensions, assess their impact on AI-assisted performance, and explore their applicability across different disciplines and professional contexts. The framework may also serve as a basis for developing assessment instruments that measure prompt engineering competencies.

Within professional environments, the framework can guide workforce development initiatives aimed at improving AI-related skills. AI technologies are being used more and more by organizations to assist with decision making, communication, content creation, and problem-solving processes. The PIERCE Framework offers a structured model that can assist employees in developing the competencies necessary to interact effectively with AI systems while maintaining ethical and professional standards.

From a policy perspective, the framework contributes to ongoing discussions regarding AI literacy and responsible AI governance. Policymakers and educational leaders may utilize the framework to inform the design of training programs, digital literacy strategies, and AI competency standards. By emphasizing both technical and ethical dimensions, the framework promotes a balanced approach to AI adoption that prioritizes effectiveness, accountability, and responsible use [40].

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Beyond its conceptual contribution, the PIERCE Framework provides a foundation for future empirical investigation. Researchers may develop measurement instruments based on the six framework dimensions to evaluate prompt engineering competencies among students, educators, professionals, and other AI users. Furthermore, empirical validation across different educational, organizational, and cultural contexts would provide valuable evidence regarding the framework's applicability, reliability, and effectiveness. These investigations would help to continually improve the framework and help to develop evidence-based AI literacy programs.

4. CONCLUSION

The rapid expansion of generative artificial intelligence has transformed the nature of digital interaction and created new competency requirements for effective human–AI collaboration. While existing digital literacy and AI literacy frameworks provide valuable foundations for understanding technology use, they often provide limited attention to prompt engineering as a distinct and essential competency. To fill this gap, this study introduced the PIERCE Framework, a conceptual framework that places prompt engineering as a digital literacy skill in the age of generative artificial intelligence.

The proposed framework consists of six interconnected dimensions: Prompt Intent Formulation, Intelligent Prompt Design, Engagement with AI, Response Evaluation, Continuous Refinement, and Ethical Application. These dimensions offer a framework for comprehending the ways in which people can engage with AI systems in a constructive, critical, and responsible manner. The framework extends existing perspectives on digital literacy by emphasizing the iterative and collaborative nature of human–AI interaction and by recognizing prompt engineering as a multidimensional competency rather than merely a technical activity.

The study contributes to the growing discourse on digital literacy, AI literacy, and human–AI collaboration by offering a comprehensive conceptual framework that can support future educational, professional, and research initiatives. The framework can help educators in curriculum development, researchers in studying the competencies of prompt engineering, and organizations in creating training programs for AI.

As a conceptual study, this research is subject to certain limitations. The framework has been developed through literature-based conceptual synthesis and has not yet been empirically validated. Therefore, future research should examine the applicability and effectiveness of the PIERCE Framework across different educational, professional, and cultural contexts. Future studies may also develop measurement instruments and empirical models to evaluate the relationships among the framework dimensions and their influence on effective human–AI collaboration. In addition, comparative studies involving established digital competence frameworks, such as DigComp 2.2, may further demonstrate the complementary role of the PIERCE Framework in supporting AI-enabled digital literacy across diverse application domains [14].

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