

Using prompt engineering to foster critical thinking in higher education

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Abstract. This paper presents a systematic review of the latest research (2023–2025) concerning the contribution of prompt design to the development of critical thinking skills in the field of AI-supported eval practices. The review combines studies of empirical and conceptual nature that are examining various prompting strategies, such as role-based, Socratic, scenario-driven, iterative, and chain-of-thought approaches. According to the findings, well designed prompts essentially stimulate the higher-order cognitive processes, which are the ones that involve the critical thinking skills of analysis, creation, and reflective reasoning and also that they lead to increased engagement and metacognitive awareness. The results additionally point to the possibility of prompt engineering to fundamentally change the role of AI as a mere informational resource to that of a co-teacher with active engagement in pedagogy, albeit with some issues still existing in the area of teacher preparation, curriculum modification, and AI literacy. In conclusion, prompt engineering is just as much a teaching practice as it is a technical skill and it is at the core of students' critical and reflective abilities development in modern learning environments.

Keywords: AI in education, prompt design, metacognition

1 Introduction

In a time when the use of AI in higher education is entering very fast, a thorough knowledge of prompt engineering skills could have a positive effect on student's capabilities [1] and would also be able to strengthen their critical thinking skills [2]. There are projects that specifically aim to introduce AI literacy in school level [3]. The primary aim of these projects is to make the students realize the responsible usage of AI, however, they can only do so if they understand how to 'communicate' with an AI to get the desired result. It, therefore, means that students need to be competent prompt engineers [2]. Prompt engineering is basically a clever and deliberate selection of inputs that will bring about the desired response or the right conduct by an AI system. As such, in education, it means the creation of such prompts that would be able to attract students' attention as well as to challenge their critical and creative thinking. The qualities of prompt engineering are found in its capacity to change the AI from a simple information source into a user-friendly tool which encourages more profound learning and

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comprehension [4]. In prompt engineering, students come up with, verify and improve prompt that would result in desired AI responses, thus immersing them in elaborate problem-solving and reflective thinking.

2 Prompt engineering and critical thinking

Existing research provides various views, some of which warn that AI applications may slow down the development of critical skills, whereas others maintain the position that AI may enhance learning if properly put in practice [5].

Methods of critical thinking are frequently discussed in the literature. Authors of [1] observe that if a learner asks an AI system to prepare a paper it deprives the student of the chance to engage in critical thinking. With the implementation of ChatGPT, there are questions about the decline of the critical thinking skills and the possible obstruction of human relations [6]. Excessive reliance on ChatGPT could result in the lowering of students' cognitive abilities, especially in critical thinking [7]. Critical thinking, by definition is the capability to assess data, reason, and come up with logical solutions, is among the crucial components of higher education, that perhaps AI application could have an influence on [8]. One of the essential skills for learners is the ability to critically think. This is especially true in college and universities where students are supposed to be independent, solve problems, and analyze the given data [9]. But, prompt engineering may be a factor to motivate students to apply their analytical and critical thinking skills, as shown in higher education contexts [10-12], in creative or experiential settings [13-15], and in classroom-based case studies [16]. By using prompts that aim to delve deeper into the topic, produce intriguing questions, or come up with practical solutions can result students to be actively engaged which in turn will higher their cognitive skills [12]. Author of [17] referred to "pivotal components" as the three elements which are the basis for an effective prompt engineering process: Content Knowledge, Critical Thinking, and Iterative Design. He states that one of the most important skills that the user must have when dealing with AI tools is critical thinking which "isn't a mere accessory but a necessity" and also say that the function of the referred skill is to assess, validate and challenge the AI tool's results. The skills that need to be developed here are the aptitude to critically analyze the content of AI responses and to accurately identify when hallucinations, biases, inaccuracies, or any other kinds of inappropriate content are present. These skills are the very basic ones that allow the user to later be able to modify prompts in a proper way.

Working with students to create efficient prompts for large language models such as ChatGPT can sharpen critical thinking capabilities [18, 19]). Moreover, ChatGPT supports user's critical thinking skills as it helps the user with self-regulation by providing frameworks for evaluating responses, thereby reinforcing reflective reasoning [20]. It is important to approach to AI from a critical perspective. One of the ways to develop the skills of prompt engineering is to carry out a critical thinking exercise [2]. The stages of constant assessment and redesigning of instructions, as shown in the prompt engineering templates found in the literature, are main features of the skill development process for human-AI interaction. Author of [21] invites to reflect on the potential

application of his CLEAR framework in teaching and asserts that this method will cultivate the critical thinking abilities of learners.

Research indicates that prompt engineering can support inclusivity and equity [2, 22] and enhance reflective or critical questioning approaches [23, 24]. Prompting strategies have been investigated across multiple disciplines, from higher education pedagogy [10-12] to creative and applied learning environments [13-15], with newer work extending into technological innovation and classroom case studies [16, 2].

A study by [24] demonstrated that AI chat models, when integrated with engineered prompts, significantly improved undergraduate students' critical thinking skills, with an average increase of 12 points in critical thinking assessments. Participants also reported high satisfaction and engagement with the AI prompts, indicating their effectiveness in stimulating deeper cognitive engagement [24]. The study also demonstrates that engineered AI prompts can measurably improve students' abilities in analysis, evaluation, and synthesis which are core components of critical thinking. Prompts functioned as structured scaffolds that moved learners from passive knowledge reception to active engagement and finally to reflective judgment.

Other research explored various strategies for prompt engineering, such as role-playing prompts and Socratic prompts, which are designed to enhance learning experiences with ChatGPT. These strategies help tailor prompts to individual needs, fostering engagement and promoting critical thinking skills [22, 25]. Study concludes that prompt engineering acts as both a pedagogical and cognitive scaffold: close prompts build foundational knowledge, open prompts stimulate higher-order reasoning, role-play prompts foster applied decision-making and empathy [22]. Socratic prompts systematically push learners into critical evaluation and reflective reasoning. The survey evidence shows teachers perceived substantial improvements in critical thinking, analytical skills, and metacognition when prompts were carefully designed and aligned with objectives.

Author of [2] emphasized the necessity of AI literacy and prompt engineering proficiency in modern education. The study discussed strategies for embedding these skills within educational curricula to enrich educational experiences and promote critical thinking [2]. It also emphasizes that prompt engineering is not only a technical skill but also a pedagogical strategy. By shifting from simple input/output prompts to chain of thought prompts, tree of thought prompts, and expert prompting, educators can design AI interactions that scaffold analysis, evaluation, reflection, and ethical reasoning which are all core aspects of critical thinking.

Authors of [23] presented the Socratic Playground for Learning (SPL), a GPT-4-based intelligent tutoring system that engages the Socratic method to stimulate the critical thinking skills. By means of prompt engineering, SPL creates educational situations, supports lesson contexts, and manages multi-turn conversations. Experimenting Socratic prompts motivate the students to ask questions, think critically, and reflect.

While these studies highlight the benefits of prompt engineering in fostering critical thinking, they also point to challenges such as the need for comprehensive educator training and curriculum adaptation. The integration of AI in education requires careful consideration of societal impacts and the development of AI literacy among educators and students alike [2].

Even with the increasing interest on AI powered educational solutions, there still remains a substantial gap between the employment of AI to generally improve teaching and learning processes and its use to develop student critical thinking skills via prompting only. This research comprehensively aims to scrutinize how prompt engineering shapes the critical thinking skills in higher education. It seeks to delineate the connection between prompt design and students' logical thinking, assessment of information, and active engagement in critical thinking. The question is which types of prompt engineering strategies in AI-supported learning environments are designed? How are they related to critical thinking outcomes?

3 Methodology

This research used a systematic literature review approach which adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework involving four main stages: identification, screening, eligibility, and inclusion [26]. A literature search was conducted using the Scopus, Web of Science and ERIC databases. The search covered publications considering time interval of the last three years (from 2023 to 2025). The goal of this systematic review is to outline the effects of prompt engineering on the development of students' critical thinking skills. Moreover, this research is intended to grasp the effect of prompt engineering on learners' capacity to critically and independently evaluate and assess information. Databases were searched by keywords: prompt engineering, critical thinking, AI in education.

Following the recognition of relevant documents, it was necessary to select the articles that qualified the inclusion parameters of the study. In order to carry out the initial screening process, various criteria were set, such as eliminating duplicate documents, implementing the exclusion and inclusion criteria, concentrating on items that were pertinent to the objective of the research and restricting the choice to English language papers openly accessible. There were 57 records identified through database searching, 29 full text articles assessed for eligibility and 12 articles included in the study. In order to understand the content of selected articles for this review a deductive thematic analysis approach was employed which consisted of defining and grouping themes on the basis of the research questions [27].

Data were extracted on: prompt types used, reported outcomes on reasoning or critical thinking, identified best practices. In final, findings were synthesized into a framework linking prompt design and critical thinking outcomes. The limitations refer on synthesizing studies with different research designs (conceptual vs. empirical).

4 Results and discussion

Following table presents synthesized types of prompt design and related outcomes on critical thinking (Table 1).

Table 1 *Prompt engineering types and critical thinking outcomes*

Prompt Types Used	Reported Outcomes on Critical Thinking / Reasoning	Study
Knowledge construction, Inquiry-based, Self-assessment, Peer teaching	Scaffolded reasoning, inquiry, metacognition, peer explanation; reduced transmissionist “answer-giving.” Sample prompt: “You are a teacher who facilitates inquiry-based learning...”	[10] – Teacher-GAIA
Objective-driven, Context-rich, Role-based, Format-specified, Iterative, Example-anchored, Ethical prompts	Promoted dialogue, reflective questioning, deeper analysis; highlighted risk of shallow reasoning if poorly crafted.	[11] – Conceptual
Goal-aligned, Example-based, Lesson planning, Problem-solving, Engagement/debate, short answer question, multiple choice questions, Assessment, essay question prompt	Supported higher-order reasoning (analysis, evaluation, synthesis), authentic assessment, divergent/convergent thinking. Sample prompt: “Craft a complex scenario related to [topic].”	[12] – HE Teaching
Empathise, Define, Contextualise, Design puzzles, Briefing, Debriefing, Prototype, Evaluation prompts	Fostered problem-solving, reflective reasoning, collaborative analysis, metacognition through game-based design. Sample prompt: “Write a debriefing guide with reflection questions...”	[13] – Escape Rooms
Descriptive, Iterative/variation, Synectic triggers, Peer reinterpretation, Ethical reflection	Encouraged conceptual refinement, divergent thinking, metacognition, ethical reflection on AI use.	[14] – Art Education
Open idea generation, Elaboration, Contextualisation, Specification, Risk assessment, Instructional, Assessment design, Self-critique	Enhanced analytical reasoning, problem-solving, reflective thinking, collaborative reasoning; required human critical validation of AI outputs. Sample prompt: “Critique your suggestion for the marine litter field activity...”	[15] – Field Course Design
Analytical, Evaluative, Synthetic, Reflective/metacognitive, Perspective-taking prompts	Measurable gains in analysis (+7.8), evaluation (+7.8), synthesis (+9.8); 83% reported broader perspectives; strong metacognitive development.	[24] – Empirical Study
Close question prompts, Open question	Survey (N=120 teachers): Prompts fostered evaluation (4.3/5),	[22] – Teacher Survey

prompts, Role-playing, Socratic prompts;	exploration (4.1/5), reflection (4.1/5); promoted perspective-taking and collaborative reasoning. Sample prompt: "Provide examples and discuss the mechanisms..."	
Input-output prompting, Zero-/Few-shot, Chain-of-thought (CoT) prompting, Self-consistency prompting, Tree-of-thought (ToT), Role-play or expert prompting, automatic prompt, generating knowledge	CoT/ToT - structured reasoning; Adversarial - critical evaluation of AI; Role-based - applied judgment; scaffolded analysis, evaluation, ethical reasoning. Sample prompt: "Provide me step by step...";	[2] – AI Literacy
Lesson creation, Socratic dialogue (What, Why, How), Adaptive feedback, Scenario-based	Graduate pilot: +80% positive on understanding/motivation; iterative Socratic prompts stimulated critical questioning, reflection, synthesis, and problem-solving. Sample prompt: "What aspect of the context do you find most challenging to understand?"	[23] – Socratic Playground (SPL)
Standard (few-shot) prompting, chain of thought prompting, ablation prompt variations	Arithmetic reasoning, commonsense reasoning, symbolic reasoning,	[28]
Expert identity prompts, instruction prompts	Evaluation and judgment, reflective and contextual reasoning, analytical and explanatory depth	[29]

Research of [10] illustrates that prompt engineering is capable of converting LLM results to switch logically from the detailed answer provision to the facilitation of the reasoning process. Such change is consistent with advanced cognitive functions from Bloom's taxonomy (analysis, evaluation, creation) and with the Paul-Elder critical thinking framework (reasoning, questioning, metacognition). Hence critical thinking, logical reasoning, and self-regulation were enhanced by the use of carefully tailored persona prompts, which elicited these skills to a far lesser extent when generic prompts were used.

Authors of [11] state that prompt engineering forms the core of constructing a "conversational pedagogy" with AI. Although the paper is conceptual (not an empirical study), it draws implications for critical thinking and reasoning in education. Good prompts can stimulate critical thinking, deeper reasoning, and co-creation of knowledge. Bad prompts can lead to the situation whereby students continue to learn only at a surface level or even get false information. Therefore, the development of critical thinking skills is very much dependent on the characteristics of prompts (clarity, context, structure, and purpose).

The study of [12] shows that carefully engineered prompts can be used by educators to: generate content that elicits critical thinking from students, scaffold problem-solving tasks, and redesign assessments to be more authentic, reflective, and reasoning-oriented. In other words, prompt engineering acts as a pedagogical design tool that supports the creation of learning tasks requiring analysis, evaluation, and argumentation which are the building blocks of critical thinking.

Well-engineered prompts transform ChatGPT from a content generator into a pedagogical design partner [13]. By embedding narrative, puzzles, reflection, and evaluation, prompts create immersive escape rooms that demand learners' critical thinking, reasoning, and problem-solving skills.

The study of [14] integrated OpenAI's DALL-E 2 into digital art courses. Students were required to design and refine prompts as part of their creative process. The study demonstrates that prompt engineering, when used iteratively and collaboratively, supports critical reasoning in at least three ways:

Cognitive – analyzing the effect of language on AI outputs (analytical thinking).

Creative – exploring divergent design possibilities (imaginative reasoning).

Ethical/Reflective – evaluating the implications of AI use in art (critical reflection).

Authors of [15] demonstrate that iterative, structured prompts can scaffold the design of field courses that foster data analysis, environmental reasoning, risk assessment, and reflective discussion. At the same time, the need for human oversight and adaptive management highlights critical thinking as both a learning outcome and a methodological safeguard. Authors of [28] established Chain of Thought (CoT) prompting as a foundational method for eliciting higher-order reasoning in large language models.

Authors of [29] demonstrate that expert identity prompting effectively scaffolds LLM reasoning by embedding domain-specific perspectives. This improves analytical depth, explanatory detail, and evaluative precision which are all central to critical thinking. Moreover, the ExpertLLaMA model trained on such data showed that systematic prompt engineering can enhance reasoning capabilities at scale.

This research underlined two different pathways by which prompt engineering has developed, teaching and algorithmic, and illustrates how they are joining together at the same result with the implications of critical thinking. Educational studies emphasize the importance of role-based dialogue and Socratic questioning [10, 11, 23], scenario-based and field applications [12, 15]), and creative integration in arts education [14]. Algorithmic approaches, by contrast, focus on refining reasoning through systematic design, as seen in chain-of-thought, self-consistency, and tree-of-thought methods [28, 16], as well as automated and expert prompts [29]. Despite their different origins, both strands converge on fostering analytical depth, reflective practice, and evaluative precision. Such method raises the reliability, correctness, and the logical framework of the reasoning system in the large language models, thus opening up new prospects of their application in education. Though the two are different from the outset, the paths of both strands meet at common critical thinking outcomes. Despite this review showcasing the capability of prompt engineering to facilitate critical thinking, it is still necessary to have more proof from real cases in college environments. A set of possible future research areas could be controlled classroom experiments, longitudinal studies, disciplinary case studies and mixed-methods approaches combined with quantitative testing

and qualitative methods (student interviews, reflective journals, classroom observations) for obtaining students' perceptions of prompts and understanding their reasoning processes.

5 Conclusion

This review demonstrates that prompt engineering spans both educational strategies and algorithmic innovations. New hybrid models are opening the way for linking these two areas with a common goal, i.e. to develop critical thinking skills through analysis, evaluation, synthesis and reflection.

When prompts are aligned with learning objectives, evidence shows quantifiable improvements in analytical reasoning, evaluative judgment, synthesis of ideas, and meta-cognitive reflection. In addition, the results highlight the need for teacher training, curriculum modification, and the teaching of critical AI literacy to guarantee that the advantages of prompt engineering are brought about and at the same time controlling the risks like simple logic or AI hallucinations.

In conclusion, designing prompt should be considered just as much a teaching skill as a technical skill, which could noticeably change the way users interact with AI, if used properly. This is because it is not only easy to access source of information anymore but an engaged partner that helps the user to learn through critical and reflective thinking.

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