Improving AI Literacy in Graduate Research Training: Integrating Prompt Engineering into Research Methods Courses

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Abstract

With the rise of generative artificial intelligence (AI) technologies, such as large language models (LLMs), scholarly research practices are undergoing a transformation. Effective use of these tools requires proficiency in prompt engineering, the practice of designing and refining prompts to interact with, build upon, and leverage the capabilities of LLMs. Despite its growing importance, prompt engineering is not yet adequately incorporated into most graduate-level research methods curricula. The present study highlights the need for its integration as a critical AI literacy component alongside traditional research skills in research design, data collection, analysis, and interpretation. The study explores the integration of a structured prompt engineering instructional module into a graduate research method course in civil and construction programs. Using a one-group pretest-posttest pilot design, both qualitative and quantitative data were collected to examine changes in students' perceived AI literacy, ethical awareness, and objective knowledge of prompt engineering concepts. The findings suggest that such instruction can improve students' perceived skills and confidence in applying LLMs to research tasks. This study provides preliminary evidence to support the inclusion of prompt engineering in graduate research training and offers practical implications for curriculum development in engineering education.

Introduction

Generative artificial intelligence (AI) technologies, especially large language models (LLMs), are increasingly being used in educational and research settings [1], [2], [3]. These tools can support many academic writing and research activities, including idea generation, content structuring, literature synthesis, data management, editing, and ethical compliance [2]. However, effective and responsible use of LLMs requires the development of prompt engineering skills, which involve designing and optimizing prompts [4]. Prompt engineering is a relatively new technical skill and an important component of AI literacy [5], [6]. Studies have emphasized its growing relevance and importance in academic settings because well-designed prompts can improve the accuracy, relevance, and reliability of LLM outputs for students and researchers. At the same time, users also need to be aware of common prompt-related pitfalls [4].

Despite its growing importance, prompt engineering remains largely absent from formal educational curricula and pedagogical practices. A recent systematic review of prompt engineering in higher education revealed that although several attempts have been made to teach prompt engineering, these practices are inconsistent, and no existing studies have compared or contrasted the different ways in which prompt engineering is being taught [7]. Without proper training in prompt engineering, students as non-experts using LLM-based AI systems may risk poor output quality or misinterpretation of AI-generated results [6]. Similar limitations are likely to exist in formal graduate-level research methods training.

In graduate research methods courses, students usually learn how to conduct literature reviews, develop research questions and designs, plan and conduct ethical data collection, apply appropriate analytic techniques, interpret study findings, and present research findings [8], [9]. However, despite the advancement of AI and its potential benefits for academic work, limited guidance on how AI should be used in scholarly research, as well as on the proper design and use of prompt engineering, may lead to irresponsible and inefficient use of LLMs in graduate research curricula and in the production of high-quality research outputs.

This study aims to address this gap by exploring the integration of prompt engineering instruction into a graduate-level research methods course in civil and construction programs. Specifically, it seeks to: (1) design and implement a pilot prompt engineering instructional module in a graduate research methods course; (2) evaluate its effects on students' perceived AI literacy, ethical awareness, and objective knowledge of prompting concepts; and (3) provide preliminary implications and recommendations to inform future integration of prompt engineering into graduate research methods curricula. By focusing on both educational outcomes and curriculum design, this study seeks to contribute to the development of research training that prepares graduate students to use generative AI tools effectively, critically, and responsibly across diverse academic contexts.

Related Work

Recent scholarly work has explored how prompt engineering can be taught in higher education. For example, Wang et al. [10] explored a flipped-classroom approach in which undergraduate students were taught and practiced prompt design for tasks such as information retrieval and content generation. In another study, Woo et al. [11] investigated an English as a Foreign Language writing course in which students were taught prompt engineering skills to support a 500-word writing task using ChatGPT during a workshop. The results indicated that, despite only a slight increase in students' motivation, students generally reported high satisfaction with the overall learning experience. In engineering education, specifically in a computer networks course, Ma et al. [12] embedded a prompt-engineering model into an agent-based instructional framework to generate learning materials that supported students' active learning. A preliminary in-class survey indicated that this approach has the potential to increase student engagement and deepen their understanding of the topics.

Similar studies have also been reported in civil and construction education. In a mathematics laboratory for civil engineering students, six structured activities integrating LLMs alongside an existing computer algebra system were shown to enhance conceptual understanding, clarify solution methodologies, and support inquiry-driven learning and mathematical reasoning [13]. Similarly, in a senior-level civil engineering course, Wijesinghe et al. [14] implemented structured generative AI writing assignments in which students were required to document their prompts, verify AI outputs, and reflect on model limitations and bias. The study also asked students to read and analyze two articles related to the use of generative AI in civil engineering practice to further reinforce that effective AI use requires careful prompting and verification.

Overall, prior studies have generally reported positive learning experiences among learners. However, the teaching methods used in these studies are quite different, including short workshops, flipped-classroom prompting exercises, agent-based instructional models, course modules, reading and reflection activities, and task-based prompt design exercises. As a result, the literature indicates that there is no consistent approach to teaching prompt engineering, and instructional formats vary widely depending on learning objectives, course structures, and disciplinary contexts.

Moreover, existing research suggests that prompt engineering skills can be learned and improved through instruction and practice. For instance, through a one-week instructional module on generative AI, researchers from New Zealand reported that explicit instruction helped civil engineering students improve their ability to interact effectively with LLMs [15]. However, the duration and intensity of instruction may play a role in learning outcomes [13]. In parallel, several studies also link prompt engineering to the development of AI literacy, as learning to craft effective prompts helps students better understand the capabilities and limitations of AI systems [5], [15].

These results support the idea that AI and LLMs should be more systematically included in engineering education. Plevris [16] highlights the growing need to integrate AI and LLMs into civil engineering and construction education to improve instructional efficiency, student engagement, and support personalized learning. Maalek [17] also showed that integrating LLMs into graduate-level construction engineering and management courses in the areas of digital engineering and construction digital technologies improved students' ability to perform professional tasks such as code generation, project planning, and problem solving. Students also reported high satisfaction and task completion rates. The study further emphasized that educating students on how to interact effectively with generative AI should be embedded into engineering curricula to prepare them for future professional practice.

At the same time, teaching research methodology in graduate-level civil and construction programs faces long-standing challenges. Previous studies have revealed that many students typically have difficulty defining the scope of research problems, formulating research questions and/or hypotheses, choosing suitable research designs, producing academic writing, and understanding the complexity and ambiguity of real-world situations [8], [18]. Accordingly, creating learning environments in which students actively engage in critical thinking and analytical reasoning instead of passively receiving information and knowledge is recommended [18]. In this regard, LLMs and prompt engineering may provide a practical way to support more interactive learning, as students can practice developing research questions, refining problem statements, and assessing AI-generated results during the process. Integrating prompt engineering into graduate research methods courses may therefore help students conduct research more effectively, use LLM-based tools more responsibly, and improve their AI literacy.

Despite these developments and educational needs, to date, no existing studies have examined the integration of LLMs, particularly prompt engineering, into graduate-level research methods courses in civil engineering and construction education. This study aims to address this gap.

Methodology

This study adopted an exploratory one-group pretest-posttest pilot study design to examine the integration of structured prompt engineering instruction into a graduate level research methods course. The primary goal of the study was to understand how structured instruction in prompt engineering influences graduate students' AI literacy, research-related skills, and ethical awareness. To achieve this goal, both quantitative and qualitative data were collected, allowing for a more comprehensive understanding of students' learning experiences and outcomes following the pilot implementation.

The pilot study was conducted in an introductory graduate level research methods course within a construction management program at a large public university in the United States. The course is the first in a two-course research methods sequence and emphasizes foundational research competencies, conducting library searches, performing literature reviews, synthesizing and comparing literature, and developing research questions, prior to a subsequent course focused on research design. The course is typically taken by first semester master's and doctoral students enrolled in the construction management or civil and environmental engineering programs and meets for 2 hours and 50 minutes per week. The prompt engineering module was implemented during the Fall 2025 semester and delivered toward the end of the course. At that point, students had already practiced these research tasks independently without the use of AI. Because prompt engineering had not been explicitly covered in any existing coursework within the programs, this course provided an appropriate setting for piloting structured prompt engineering instruction in graduate research education.

The prompt engineering module was developed based on multiple existing sources such as [19], [20], [21], [22], and was intentionally designed to frame prompt engineering as a research-oriented skill rather than a general AI usage technique. Specifically, the module included:

- an overview of how LLMs function and their limitations;
- core prompt engineering techniques, including:
    - Example-based prompting: zero-shot (no example is given), one-shot (one example is given), and few-shot (several examples are given);
    - Role prompting: the prompt asks the model to act in a certain role, persona, or perspective;
    - Contextual prompting: specific and detailed background information, conditions, or constraints are provided to guide the response;
    - Chain-of-thought prompting: the prompt asks the model to break down a problem into step-by-step reasoning before giving the answer;
    - Automatic prompt engineering: prompts are created and improved automatically through repeated testing;
- best practices for prompt design; and
- ethical considerations related to bias, hallucination, academic integrity, and data privacy.

To support the development of research-relevant skills, students engaged in hands-on activities aligned with graduate research tasks already introduced in the course or will be introduced in the subsequent research methods course. This alignment supported face validity, as the activities reflected real research tasks that graduate students are expected to perform. These activities included generating keywords for literature searches using zero-shot prompting, structuring literature summaries via one-shot prompting, critiquing research questions using role prompting, and refining research designs via contextual prompting. In addition, students participated in a visual scenario generation challenge, in which they were asked to generate a visual representation of a real construction accident case. All activities were delivered using the same instructions, prompts, and time limits for all students to ensure consistent implementation. To maximize effective use of in-class time, a GitHub-based webpage was created to facilitate the activities, allowing students easy access to pre-prepared prompts and instructions rather than requiring them to type prompts manually.

During the class session, after completing each activity, students were asked to respond to short reflection questions regarding their experiences using specific prompt engineering techniques. These reflections allowed the instructor to better gauge student learning and engagement. In addition, two structured surveys, a pre- and a post- survey were administered to assess changes in students' knowledge, skills, and attitudes related to prompt engineering and AI use in research.

The pre-survey was administered prior to the instructional module and collected data on demographic and academic background information, prior exposure to research methods courses and AI tools, frequency and purpose of AI use, self-reported confidence in AI literacy and prompt engineering skills, ethical awareness related to AI use, and objective knowledge of prompt engineering concepts. The survey included questions in multiple formats, including Likert-scale items, multiple-choice questions, and knowledge-based items. The post-survey was administered immediately after the module concluded and repeated the sections on AI perceptions, skills, and objective knowledge from the pre-survey to allow for direct comparison. In addition, it included open-ended reflection questions that allowed students to describe newly recognized benefits, perceived risks, and intended changes in their AI usage habits following the module.

Prior to data collection, the study instruments and procedures were approved by the Institutional Review Board at Colorado State University (IRB #7382; approved October 21, 2025). Participation in the surveys was voluntary, and students completed informed consent before participating. To preserve anonymity while allowing pre-post comparisons, participants used unique identification codes that were entered across both surveys. For those who chose not to participate in the surveys still received the full instructional module but were excluded from data collection and analysis. The survey instruments were also reviewed by three faculty members from civil and construction management programs in the United States with general knowledge of AI. This review supported face validity, confirming that the items were appropriate and relevant to graduate research and AI use, and content validity, confirming adequate coverage of prompt engineering, AI literacy, and ethical considerations.

For data analysis, quantitative data from Likert-scale and objective knowledge questions were analyzed using descriptive statistics to identify trends and changes between pre- and post- survey responses. Given the pilot nature of the study and the limited enrollment size, inferential statistical analyses were not performed. Qualitative responses from open-ended post-survey questions were analyzed descriptively to identify recurring themes related to perceived benefits, risks and challenges, and intended changes in AI usage.

Results

Participant Overview

In Fall 2025, six graduate students enrolled in the introductory graduate-level research method course in which the prompt engineering module was implemented. Of these, five students completed both the pre- and post-surveys and were included in the analysis. Participants were primarily enrolled in the construction management program, with one student enrolled in the civil and environmental engineering program. Most participants were in their first year of graduate study.

The majority of participants reported prior exposure to AI tools, with ChatGPT being the most used platform, followed by Gemini and Claude. Some participants also reported using Perplexity and Google NotebookLM. However, none indicated having received prior formal instruction in prompt engineering. Regarding weekly academic and research-related use of AI/LLMs, one participant reported using these tools for an average of 30–59 minutes, two reported one to three hours, and two reported more than six hours. In terms of baseline AI usage, participants most frequently reported using AI for literature searching and summarization. Other common uses included brainstorming and research idea generation, writing and editing text, creating figures and tables, and simulating peer review or feedback. One student also indicated using AI to support learning through simplified examples.

Pretest and Posttest Comparisons

AI Literacy and Prompt Engineering Skills

Participants rated their self-assessed AI literacy and prompt engineering skills on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Figure 1 summarizes the pre- and post-training results. Prior to the training, participants already reported relatively high confidence in the usefulness of LLMs for improving efficiency in literature review, which further highlight the importance of integrating structured AI literacy training into graduate-level research methods courses.

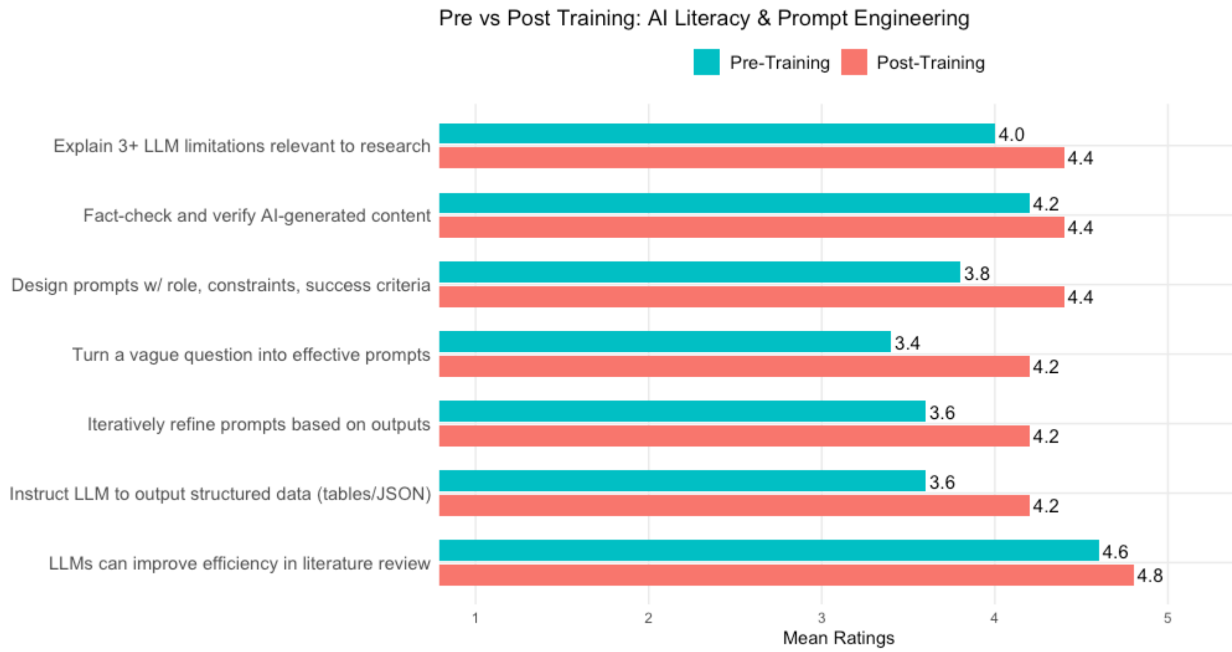

Figure 1. Pre- and Post- Training Assessments Results on AI Literacy and Prompt Engineering Skills

Across all measured items, mean ratings increased from pre- to post-training, suggesting improvements in perceived competence. The most pronounced gains occurred in prompt engineering skills, particularly participants' ability to transform vague or underspecified questions into effective prompts. Comparable improvements were observed in iterative prompt refinement based on unsatisfactory outputs, the formulation of prompts with explicit roles, constraints, and success criteria, and the ability to instruct LLMs to produce consistent and well-structured outputs. More modest gains were observed for evaluative skills, such as explaining the limitations of LLM outputs in research contexts, followed by the ability to fact-check and verify AI-generated content and to improve efficiency in literature review.

Ethical Awareness and Responsible AI Use

Participants also responded to a set of items assessing ethical awareness and responsible AI use using the same 5-point Likert scale. Table 1 reports the corresponding pre- and post-training self-reported results. Overall, positive gains were observed in participants' perceived ability to use AI tools responsibly, with notable gains in average ratings for data privacy practices and ethical disclosure awareness. In contrast, ratings related to understanding model bias and hallucinations for responsible AI use remained unchanged, while concern about plagiarism or bias declined after training. Furthermore, in general, post-training standard deviations (SDs) were generally lower for several items, indicating increasing consistency in responses.

Table 1. Pre- and Post- Training Assessments Results on Ethical Awareness and Responsible AI Use

Statement	Pre-Training		Post-Training		Change (Post – Pre)	
	Mean	SD	Mean	SD	Mean	SD
I can identify when disclosure of AI use is ethically required.	4.0	1.2	4.4	0.5	0.4	-0.7
I understand the risks of model bias and hallucination.	4.4	0.5	4.4	0.9	0	0.3
I know how to safeguard sensitive or private data when using AI tools.	3.2	1.3	4.2	0.8	1.0	-0.5
I am confident I can use LLMs without compromising academic integrity.	4.2	0.4	4.6	0.5	0.4	0.1
I intend to use LLMs in my research responsibly.	4.6	0.5	4.6	0.5	0	0
I am concerned about plagiarism or bias when using LLMs.	4.2	0.8	3.6	1.1	-0.6	0.3

Objective Knowledge of Prompt Engineering

Objective understanding was assessed using the same set of multiple-choice questions administered at both pre- and post- training to evaluate changes in participants' knowledge of key AI prompting concepts. Summary results are presented in Table 2. Performance improved for concepts related to hallucination detection, reducing hallucinated citations, and prompt reproducibility. Several concepts showed stable performance, while declines were observed in concepts involving prompt selection strategies and ethical disclosure, suggesting areas that may benefit from additional clarification or instructional emphasis.

Table 2. Pre- and Post- Training Assessment Results for AI Prompting Concepts

Concept Assessed	Pre-Training (% Correct)	Post-Training (% Correct)	Change (Post – Pre)
Hallucination detection	80	100	+20
Reducing hallucinated citations	60	80	+20
Chain-of-thought prompting	100	100	0
Zero-shot vs. few-shot prompting	80	60	-20
Prompt reproducibility	80	100	+20
Automatic prompt engineering	60	60	0
Data privacy and safety	80	80	0
Ethical AI disclosure	80	60	-20

Student Reflections

The open-ended responses from the post-survey were analyzed to understand students' perceived benefits, risks and limitations, and planned changes in their use of generative AI tools. Regarding perceived benefits, students frequently described LLMs as helpful for brainstorming and for providing initial research direction or alternative perspectives. Students also noted that LLMs can quickly summarize complex academic papers, which they indicated could be incorporated into their existing literature review workflows. Regarding perceived risks and challenges, students reported greater awareness that heavy reliance on AI tools could limit independent reasoning and critical thinking. Concerns about academic integrity were frequently raised, particularly regarding how to remain aligned with ethical expectations when using AI in academic work. Students expressed uncertainty about how much AI use is acceptable in graduate research and where to draw the line between appropriate support and misuse.

In addition, students reported increased awareness that LLMs may generate incorrect or hallucinated information, especially when prompts are poorly structured. As a result, students perceived a greater need for careful verification and cross-checking of AI-generated outputs, which some students described as an additional burden in their research workflow. When discussing planned changes in their AI usage habits, two main clusters emerged. The first focused on the use of more structured and intentional prompting strategies, such as the adoption of few-shot prompting with examples and more careful prompt design before interacting with LLMs. The second cluster emphasized the importance of independent thinking and verification, such as engaging in initial sense-making before using AI tools and then using LLMs to organize or refine ideas, as well as checking clarity and verifying outputs.

Discussion

This study examined the integration of prompt engineering instruction into a graduate research methods course and its effects on students' perceived prompt engineering understanding and skills and their application to fundamental research practices. The findings indicate that structured training could enhance these skills and foster AI literacy. Students reported stronger perceived abilities in designing and refining prompts and in generating structured outputs, which are increasingly useful for core research tasks such as conducting comprehensive literature searches, synthesizing prior research, and formulating and refining research questions. These findings are consistent with prior research showing that prompt engineering is a learnable and necessary skill for goal-directed use of generative AI tools [6], [7] and could support early-stage research activities [1], [2].

In contrast, improvements in evaluative skills (e.g., recognizing limitations of LLMs and verifying AI-generated information) and ethical understanding (e.g., model bias and hallucinations) were more limited. This may be related to the short duration of the intervention (a single course module lasting less than three hours). This observation is consistent with previous studies showing that the duration and intensity of instruction can significantly influence learning outcomes [13]. These findings may also suggest that while students may quickly acquire prompt engineering strategies for interacting with LLMs and show some improvement in AI literacy (as reflected in their understanding of prompt engineering concepts), the development of critical evaluation and ethical skills likely requires longer-term learning, repeated practice, more concrete examples, and more extensive experience in conducting research and using AI tools [5]. These competencies may need to be reinforced throughout graduate education.

Another notable finding was the decrease in students' perceived concern about plagiarism and bias after the training. It could be because participants became more confident in their capacity to identify and mitigate these risks. However, it may also suggest that increased familiarity with AI tools may boost degrees of overconfidence. Students' reflections further reinforce these points. Many described LLMs as helpful for early-stage research tasks but also expressed concern about overreliance on AI tools and the need to maintain independent thinking. Training in prompt engineering and LLMs should emphasize not only how to obtain useful outputs from these systems, but also how to evaluate their reliability, remain cautious about bias and other limitations, and recognize the importance of ethical and transparent use of AI [5], [16].

This study reinforces the importance of formally incorporating prompt engineering into educational curricula, particularly in research methods training. As LLMs become part of common research workflows, graduate students need explicit and structured instruction on how to interact with these tools responsibly to support their scholarly work, rather than replace their independent critical thinking. Prompt engineering should be introduced as a supporting component alongside traditional methodological training, not as a replacement. This is particularly important for civil and construction disciplines, as research in these fields often informs practical engineering and management decisions with real-world consequences, making ethical use and careful verification essential.

Although this study provides valuable contributions through a preliminary investigation of integrating prompt engineering training into a graduate-level research methods course, it has several limitations. First, the study was based on a single short module, so the results mainly reflect short-term effects on students' perceptions and knowledge of LLMs rather than long-term impacts. Second, the study used a one-group pretest-posttest design without a control group, which makes it difficult to conclude that the observed changes were caused solely by the prompt engineering intervention, as other factors such as prior experience with AI tools may also have influenced the results. Third, the sample size was small and drawn from a single university, which limits the generalizability of the findings. In addition, the study relied primarily on self-reported survey data and short reflective responses, which do not directly capture actual improvements in prompt design or research quality. Future research is recommended to include larger samples, control groups in experimental designs, tracking of longitudinal effects, and more objective measures of research outputs to better evaluate the effectiveness of prompt engineering instruction across multiple institutions and disciplines. Although the study focused on graduate students, the implications may extend to undergraduates. Future studies could include students engaged in research-related academic tasks, particularly those completing term papers or senior theses, to gain broader perspectives on how structured instruction guides appropriate AI use.

Conclusions

This study presents preliminary evidence on integrating prompt engineering instruction into graduate-level research methods education in civil and construction programs. By designing, implementing, and examining a research-oriented instructional module, the study demonstrates that prompt engineering can be incorporated into existing graduate research training and aligned with core learning objectives. Study participants generally reported positive learning experiences, improved perceived prompt engineering skills and AI literacy, and greater confidence in applying these skills to early-stage research tasks. The study also highlights the necessity that, in prompt engineering instruction, in addition to the technical aspects of structured training, emphasis should also be placed on critical evaluation and ethical responsibility, as these skills may require consistent long-term education and reinforcement.

This work contributes to the growing discussion on AI literacy in higher education by highlighting the need for more structured, systematic, and responsible approaches to incorporating AI-related skills into graduate education. Although this study is exploratory, it provides a foundation for future research and educational initiatives related to updated curriculum design that includes AI components and the examination of long-term learning outcomes, with the goal of maintaining academic and research integrity while embracing the use of emerging technologies.

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