IJEMST International Journal of Education in Mathematics, Science and Technology

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The Role of Prompt Writing in AI-Supported Teaching: Views of Prospective Science Teachers

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Article Info

Article History

Received:
6 August 2025

Revised:
21 December 2025

Accepted:
15 January 2026

Published:
27 March 2026

Keywords

Artificial intelligence
AI literacy in teacher education
AI-supported learning
Prompt engineering

Abstract

Central to the efficacy of AI-driven applications is the quality of prompts the input commands or texts that guide AI systems in generating accurate and meaningful responses. This study investigates science pre-service teachers' perceptions of the prompt writing process within AI tools. Utilizing a qualitative case study approach, data were gathered from 32 science pre-service teachers in their second, third, and fourth academic years through an open-ended questionnaire designed by the researchers. Content analysis was independently performed by two coders, with inter-coder reliability measures ensuring consistency. The findings indicate that participants regard prompt writing as crucial for language and expression, scientific rigor, and user engagement, though its contribution to fostering creativity and critical thinking was viewed as limited. Additionally, respondents highlighted the significance of factors such as topic selection, clarity of objectives, and precise language in constructing effective prompts. Challenges were identified both on the user side including language proficiency and articulation and on the AI side, particularly regarding scientific accuracy and maintaining focus on intended goals. Based on these results, the study recommends the design of targeted educational interventions and AI tool enhancements that address both pedagogical and technological competencies to facilitate more effective prompt generation.

Citation: Karakaya, F., Caner, Ş. N., Çakmak, Z., Eser, E., & Bal, B. N. (2026). The role of prompt writing in AI-supported teaching: Views of prospective science teachers. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 14*(3), 737-755. https://doi.org/10.46328/ijemst.5643

ISSN: 2147-611X /

Introduction

Artificial intelligence (AI) is rapidly transforming numerous fields by enabling technological systems to perform human-like cognitive functions. Drawing upon interdisciplinary approaches such as machine learning, deep learning, natural language processing, and computer vision, AI has become particularly prominent in tasks including data analysis, problem solving, decision making, and forecasting. The integration of these advancements into education offers significant opportunities to personalize instruction, enhance learning efficiency, and strengthen interactions between teachers and students. AI-supported educational applications facilitate the creation of pedagogically differentiated and more effective learning environments by providing tailored solutions that address individual learner needs. Recent research highlights the critical role of prompt engineering in enhancing educational outcomes through generative AI tools (Chen et al., 2024).

Empirical studies suggest that AI technologies can effectively support personalized learning, increase knowledge acquisition, and bolster students' motivation via smart learning tools (Ahmad et al., 2022; Hwang et al., 2020). However, realizing these benefits sustainably and inclusively requires comprehensive consideration of the evolving roles and digital competencies of teachers. In particular, understanding how teachers' pedagogical approaches, ethical sensibilities, and technological literacies develop within AI-enhanced learning environments is essential (Markauskaite et al., 2022). Teachers play a pivotal role in designing meaningful learning experiences that deepen students' understanding and foster their capabilities (Ng et al., 2023). Despite this, many teachers lack sufficient digital preparedness to effectively integrate AI-supported educational applications into their teaching practices (Ally, 2019). Specifically, they often do not possess the technological expertise required to analyze data or to program AI tools for automatic assignment generation and feedback provision (Seo et al., 2021). Therefore, fostering digital literacy among teachers and students is imperative for the successful integration of modern technologies into education (Pihir et al., 2018). Moreover, AI empowers students to engage with information technology for program design and system development, thereby enhancing educational quality and skill acquisition (Zhou, 2023). Nevertheless, compared to other sectors, the adoption of AI in educational settings remains limited (Luckin & Cukurova, 2019). This limitation stems primarily from the underutilization of AI's potential in education (Luckin et al., 2022) and insufficient recognition of teachers' roles in embedding AI within learning environments (Seufert et al., 2021).

The Use of AI in Education and Prompt Writing

AI-enhanced learning denotes the application of innovative technologies to improve teaching and learning processes (Zhou, 2023). These technologies not only facilitate learning conditions but also promote students' cognitive development, adaptability, and problem-solving skills (Chen et al., 2020). The widespread adoption of AI tools based on natural language processing such as ChatGPT, Copilot, and Gemini necessitates users' ability to communicate effectively with these systems. Research has demonstrated that large language models (LLMs) can enrich educational experiences by supporting adaptive, personalized, and self-directed learning methodologies (Knoth et al., 2024; Ruwe & Mayweg-Paus, 2023; Zhu et al., 2023). Additionally, these tools provide timely feedback, enhance accessibility to information, improve student performance and motivation, and contribute to

teaching quality (Alves de Castro, 2023; Su & Yang, 2023). Within this context, prompt writing the craft of formulating inputs to AI systems has emerged as a critical determinant of the quality of user–AI interaction (Geroimenko, 2025). A prompt, defined as the instruction or command given to an AI system, directly shapes the quality of the output received (Liu et al., 2023).

Effective use of AI in education depends heavily on the quality of user-generated prompts, which serve as guiding texts, commands, or questions for AI tasks (Lo, 2023). Well-constructed prompts enable AI systems to produce outputs that are meaningful, coherent, and pedagogically valuable (Aktaş, 2025). According to Giray (2023), prompt writing encompasses four fundamental components.

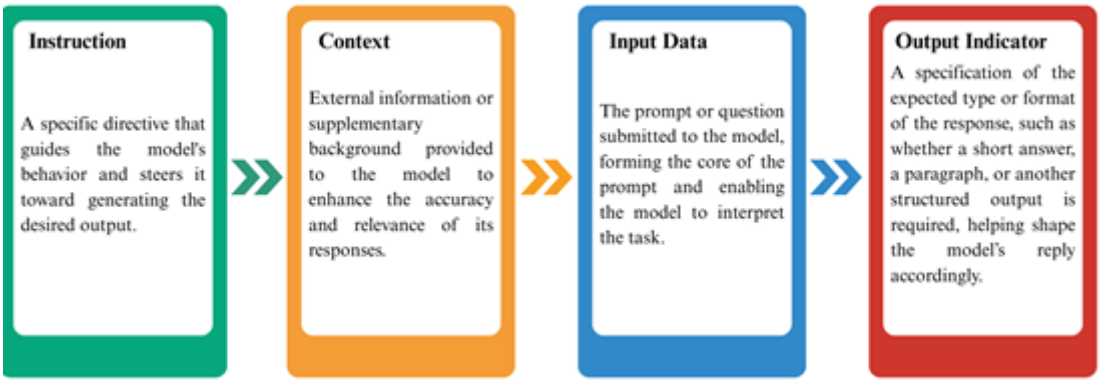

Figure 1. Prompt Writing Encompasses Four Fundamental Components Giray (2023)

Understanding these elements is essential for effective communication with AI models. Careful prompt construction guides AI behavior and enhances response quality, thereby maximizing educational utility (Jiao et al., 2023).

The Importance of Writing the Right Prompt

In educational settings, both teachers and students require not only access to technological tools but also the ability to craft meaningful prompts to utilize AI-based applications effectively. This competence enhances the pedagogical functionality of AI tools and supports higher-order cognitive processes such as critical thinking, inquiry, and knowledge structuring (Kim et al., 2021). Effective prompt writing entails clear, goal-oriented, context-rich, and structured communication (Zhou, 2023).

The process should be considered through the lens of Technological Pedagogical Content Knowledge (TPACK), as contemporary educators must integrate technological understanding with pedagogical and content expertise (Mishra & Koehler, 2006). Prompt writing facilitates more effective teacher–student interactions with AI, offering opportunities for monitoring, evaluating, and personalizing learning. Teacher candidates' proficiency in prompt writing contributes both to their technological literacy and adoption of innovative teaching practices. This underscores the vital role of prompt engineering in optimizing AI for educational purposes (Chen et al., 2024). Incorporating prompt engineering activities into teacher education is therefore critical to developing candidates'

AI literacy and digital pedagogical skills. This is particularly important in science education, where critical thinking, problem solving, and scientific inquiry are prioritized, necessitating the integration of technology with these core skills.

Purpose and Significance of the Study

This study aims to examine science teacher candidates' perceptions of the prompt writing process in AI tools using qualitative methods. It seeks to identify the challenges encountered, perceptions held, and areas for improvement in prompt creation. The findings intend to inform both teacher education programs and the design of AI-supported instructional applications.

Effective communication with AI tools and maximizing their educational potential depend on teacher candidates' digital and pedagogical competencies. This highlights the need to embed AI literacy within teacher training curricula to prepare candidates for the effective use of AI in teaching (Kim et al., 2025). AI tools can create responsive learning environments that consider not only what students learn but also how they learn and experience learning (Zhou, 2023). Furthermore, students contribute to emerging fields such as learning analytics, quality assessment of educational resources, and the development of skills aligned with labor market demands (Huang, 2021). Given the pivotal role prospective teachers will play in educational contexts, their proficiency with AI technologies is essential for delivering high-quality instruction. Accordingly, it is critical to comprehensively examine how teacher candidates utilize AI in practice and to bridge the gap between professional development offerings and actual teacher needs (Tan et al., 2025). Exploring science teacher candidates' perspectives on prompt writing will provide valuable insights for updating teacher education and improving AI-based teaching materials.

Method

Research Design

This research used the case study method, which is one of the qualitative research methods. A case study is a research method that evaluates a current phenomenon within its own real-life context and examines events/situations in a multifaceted, systematic, and in-depth manner (Yıldırım & Şimşek, 2018). With its ability to customize instructional materials and pedagogical approaches, artificial intelligence holds promise for supporting students who struggle to adapt to conventional classroom environments by addressing their unique learning needs (Rakap, 2024). The incorporation of advanced language models like GPT into educational contexts represents more than a superficial improvement; it has the potential to serve as a foundational element of contemporary pedagogical and learning frameworks (Walter, 2024). Despite the increasing integration of AI tools in education, the prompt engineering practices of pre-service teachers an essential element in effective AI use remain under-researched. In this study, a case study was chosen to reveal in detail the issues that science teacher candidates pay attention to when writing prompts in AI applications, the problems they encounter, and their suggestions for improving the prompt writing process.

Participants

The research group consisted of 32 pre-service science teachers studying at a university in the Central Anatolia region of Turkey. The research was conducted during the fall semester of the 2024-2025 academic years. Participants were informed about the study and their participation was based on voluntary consent. Demographic information about the pre-service teachers who participated in the research is presented in Table 1.

Table 1. Demographic Information of Pre-service Science Teachers

Demographic information	Variable	f	%
Gender	Female	22	68.75
	Male	10	31.25
AI Frequency of Use	Rarely	5	16.63
	Moderately	20	62.50
	Frequently	7	21.88
AI Purpose of Use	Homework	23	41.07
	Research	14	25.00
	Other	19	33.93
Total		32	100.0

Data Collection Tool

An open-ended interview form prepared by researchers was used to collect data. Two (2) different field experts were consulted to ensure the validity of the open-ended interview form. The final version of the form was created after the necessary corrections were made. The open-ended interview form consists of two sections. The first section contains questions aimed at determining the demographic information of the teachers. The second section contains five (5) different questions prepared in line with the purpose of the research. At the beginning of the form, it was stated to the pre-service teachers that ethical rules would be adhered to and that participation was based on voluntary participation.

Data Analysis

The data were analyzed using inductive content analysis, a qualitative approach that facilitates the systematic identification of themes and patterns within textual data. Content analysis enables researchers to code qualitative information in a structured manner by categorizing it into themes and sub-themes, thereby revealing meaningful relationships within the data set (Cohen, Manion, & Morrison, 2007; Fraenkel, Wallen, & Hyun, 2012; Yıldırım & Şimşek, 2018). To ensure analytical rigor, each transcript was independently reviewed by two researchers to gain a holistic understanding of participants' responses. Through iterative reading and open coding, recurring expressions and semantic patterns were identified. These initial codes were then grouped into sub-themes and overarching categories through a process of abstraction. Inter-coder reliability was assessed using the formula proposed by Miles and Huberman (1994): Reliability = Consensus / (Consensus + Disagreement). The agreement

between the two coders yielded a reliability coefficient of 94.0%, which exceeds the commonly accepted threshold of 80% for qualitative research. Discrepancies in coding were subsequently resolved through collaborative discussion until full consensus was reached, thereby enhancing the trustworthiness and consistency of the coding process. This analytic approach ensured that the findings emerged inductively from the data rather than being imposed by predetermined categories, allowing for a nuanced understanding of participants' perspectives on prompt writing within AI-supported educational settings.

Results

This section presents the findings obtained in the study. The study first aimed to evaluate the importance of prompt writing in artificial intelligence applications from the perspective of pre-service teachers. The findings are presented in Figure 1.

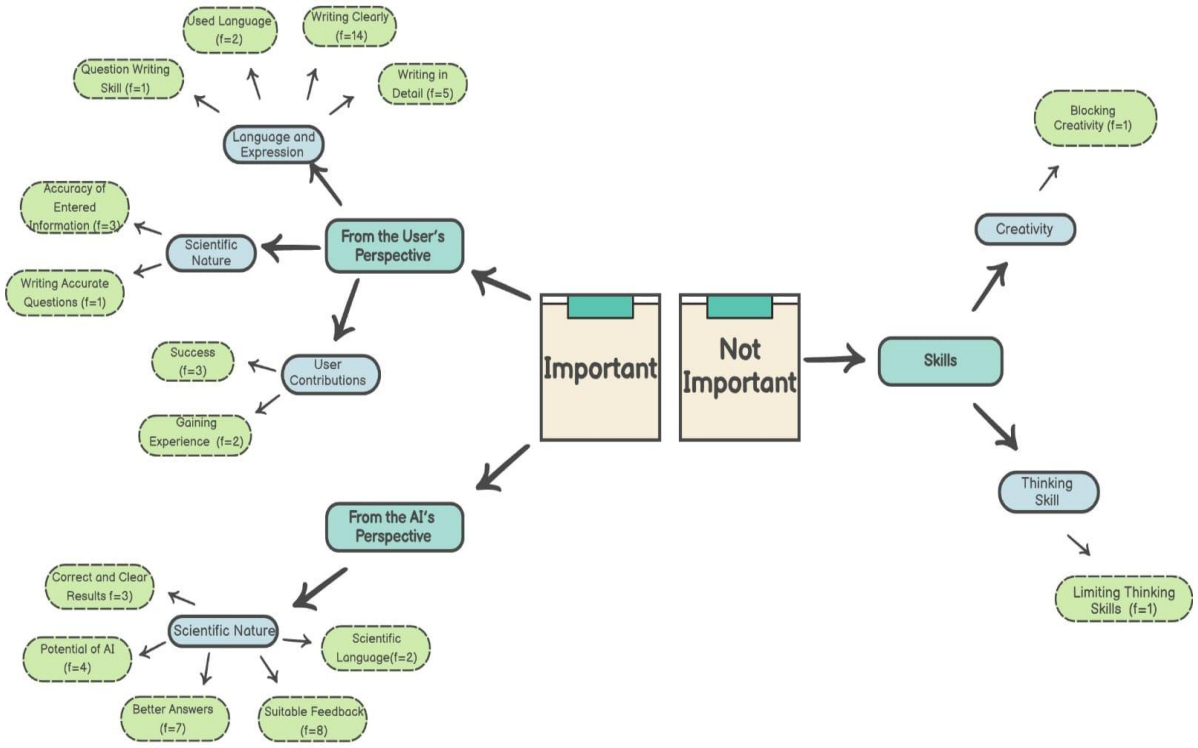

Figure 2. Pre-Service Teachers' Evaluation of The Importance of Prompt Writing

An analysis of the findings presented in Figure 2 reveals that pre-service teachers evaluated the importance of prompt writing in AI applications under two main categories: important and not important. Within the not important category, two key themes emerged: creativity and thinking skills. In contrast, the important category was divided into two overarching themes: user-related and AI-related perspectives. Participants emphasized that, during their interactions with AI tools, certain factors such as clarity of expression, scientific rigor, and user benefit were particularly significant. Regarding language and expression, participants stressed the importance of posing clear, comprehensible, and grammatically accurate prompts. In this context, the sub-themes of clear expression (f=14), detailed writing (f=5), language use (f=2), and question formulation skills (f=1) were frequently noted.

From a scientific perspective, participants underlined the necessity for providing accurate and academically sound input to AI systems. Sub-themes such as accuracy of information (f =3) and formulating accurate questions (f=1) were identified in this regard. In terms of user-related benefits, participants reported gains such as academic success (f=3) and increased experience (f=2), suggesting that AI use contributes positively to learning processes. From the AI perspective, participants evaluated the quality and scientific appropriateness of feedback received from the system. The most frequently emphasized theme here was scientific reliability. Participants stressed that AI responses should be both scientifically accurate and easily understood. Sub-themes such as appropriate feedback (f=8), more effective answers (f=7), AI potential (f=4), accurate and clear results (f=3), and scientific language (f=2) were identified within this dimension. Within the not important category, a minority of participants expressed concerns about the potential impact of AI use on individual skills. Specifically, some suggested that excessive reliance on AI could limit critical thinking (f=1) or creativity (f=1). These concerns highlight possible negative effects of AI on personal productivity and cognitive independence. Sample participant responses are provided below:

> *T-2: Yes, I believe so. Because AI has a scientific language, but it lacks actual intelligence. That's why we need to formulate the questions ourselves. T-14: Yes. The more detailed our prompt is, the more accurate and specific the response we receive from AI. T-21: Yes. Sometimes AI helps with topics I am unfamiliar with. However, relying on it all the time is not ideal it may limit our thinking and creativity. T-28: Important. Because we should fully utilize the potential of AI.*

The second focus of the study was to evaluate the elements that pre-service teachers consider important when writing prompts in AI-based applications. The findings related to this objective are presented in Figure 3.

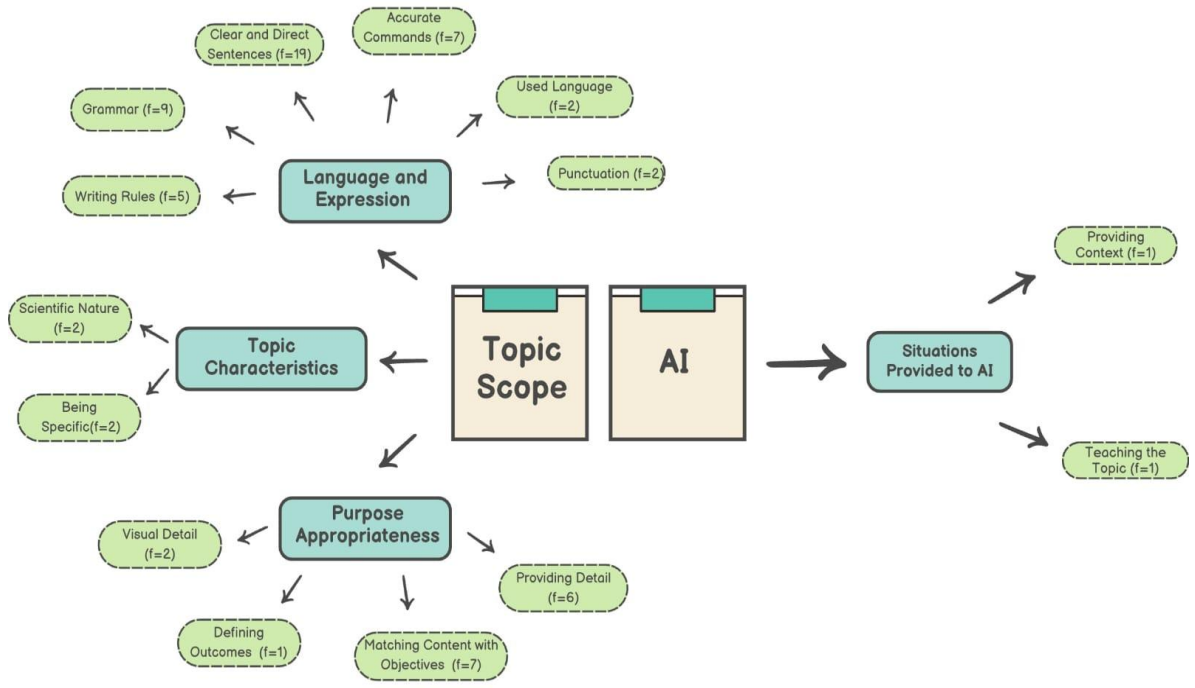

Figure 3. Key Considerations in Prompt Writing

An examination of the findings presented in Figure 3 reveals that pre-service teachers evaluated the critical

elements of prompt writing in AI-based applications under two main categories: content scope and AI-related factors. Within these categories, four overarching themes and several sub-themes were identified: language and expression, the nature of the selected topic, goal alignment, and contextual input provided to the AI. Participants frequently emphasized the linguistic structure and format of the inputs submitted to the AI. In particular, the need for clarity, accuracy, and grammatical correctness was repeatedly highlighted. The most frequently cited sub-theme was using clear and unambiguous sentences (f=14), followed by generating accurate commands (f=7) and grammar (f=9). In addition, technical aspects such as spelling rules (f=5), language used (f=2), and punctuation (f=2) were also noted by participants. These findings indicate that the quality of AI-generated responses is highly dependent on the linguistic precision of the user-provided input. With respect to the nature of the topic, participants emphasized that the characteristics of the query submitted to the AI significantly influence the relevance and specificity of the responses. The sub-themes scientific rigor (f=2) and specificity (f=2) suggest that narrowly defined and focused topics enhance AI performance. Another frequently mentioned theme was the alignment between the prompt content and the intended outcome. In this regard, defining the topic and objective (f=7) and providing sufficient detail (f=6) were the most prominent sub-themes. Less frequently mentioned but noteworthy considerations included visual detail inclusion (f=2) and identifying learning outcomes (f=1), highlighting the multifaceted nature of prompt design. These findings collectively underscore the importance of clearly articulating the intended purpose when interacting with AI tools to generate high-quality outputs. A number of participants also noted the need for supplementary explanation and contextualization to enhance AI performance. Sub-themes such as providing background context (f = 1) and teaching the topic to the AI (f=1) reflect the necessity of equipping AI with sufficient prior information and user guidance for optimal results. Selected participant responses are presented below:

> *T-4: Prompts should follow grammar rules (e.g., subject–predicate agreement) and be tailored to the expected response. T-22: To conduct an effective search, we need to structure our query properly for the AI. That's why attention to writing conventions is essential. T-25: Writing for accurate content; visual detail for suitable imagery; learning objective for research alignment; punctuation to avoid sentence-level errors. T-26: Writing, punctuation, font size, and layout matter. A well-structured page is more visually appealing and easier to process.*

The study also aimed to examine the challenges experienced by pre-service teachers during the prompt writing process in AI-based applications. The findings related to this objective are presented in Figure 4. An analysis of the findings in Figure 4 reveals that the challenges pre-service teachers faced during prompt writing in AI applications were categorized into two groups: challenging and not challenging. The majority of participants reported that the difficulties they experienced were primarily user-related. Within the domain of language and expression, the most frequently cited challenge was lack of clarity in articulation (f=7). Other issues included incomplete statements (f=1), inability to provide detailed information (f=5), difficulty in formulating appropriate questions (f=1), and inability to construct coherent sentences (f=1). These findings suggest that the way participants expressed themselves directly influenced the quality and relevance of the responses generated by the AI. In terms of language use, participants noted difficulties such as inability to articulate prompts verbally (f=5) and struggles with command formulation (f = 3), indicating challenges in verbal expression and directive language skills. Under the theme of other issues, several cognitive and procedural limitations were identified, including

failure to state the intended goal (f=3), lack of contextualization (f=2), ethical concerns (f=1), inability to maintain chronological order (f=1), and deficiency in critical thinking skills (f=1). These results suggest that participants experienced difficulties not only in linguistic aspects but also in cognitive and ethical dimensions of prompt construction.

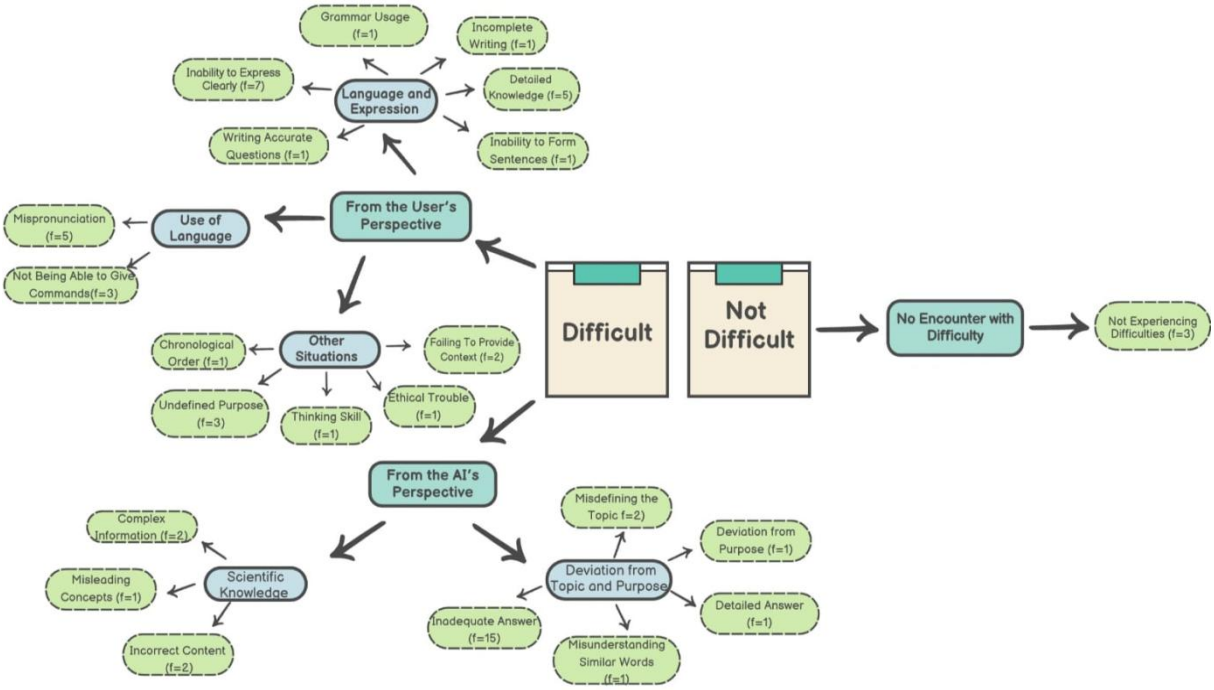

Figure 4. Challenges Encountered During the Prompt Writing Process

From the AI-related perspective, some challenges were linked to the limitations of the AI system itself. Within the theme of scientific information, participants reported issues such as overly complex information presentation (f=2), conceptual inaccuracies (f=1), and incorrect content (f=2), all of which point to concerns regarding the accuracy and reliability of AI-generated responses. Another dominant theme was misalignment with topic and objective, with inadequate responses (f=15) being the most frequently reported sub-theme. Other related problems included misidentification of the topic (f=2), misinterpretation of similar words (f=1), lack of detail in responses (f=1), and deviation from the intended purpose (f=1). These findings indicate that AI outputs may suffer not only from linguistic deficiencies but also from semantic and contextual shortcomings. A smaller group of participants reported no challenges during their use of AI. These responses were grouped under the code absence of difficulty (f = 3), indicating that the user experience may vary considerably depending on individual profiles and usage contexts. Sample participant responses are provided below:

> *T-3: The most difficult challenge I faced was the AI misinterpreting similar words. T-5: I didn't encounter any major issues. When the AI didn't organize the information as I expected, I just provided more details. T-6: Lack of thinking skills and difficulty in forming sentences were challenges. T-7: There were times I couldn't reach the exact result I wanted; sometimes the responses were overly complex. T-11: Occasionally, the AI provides vague or incomplete feedback; sometimes there are conceptual errors in its responses. T-18: Either the answer is incorrect, or the question is misunderstood, and sometimes it gives the same response despite varied inputs. T-19: When I write prompts about topics I know little*

about, the words I use tend to mislead the AI.

The fourth aim of this study was to examine the challenges encountered by pre-service science teachers in the prompt writing process within AI applications. The results of this analysis are presented in Figure 5.

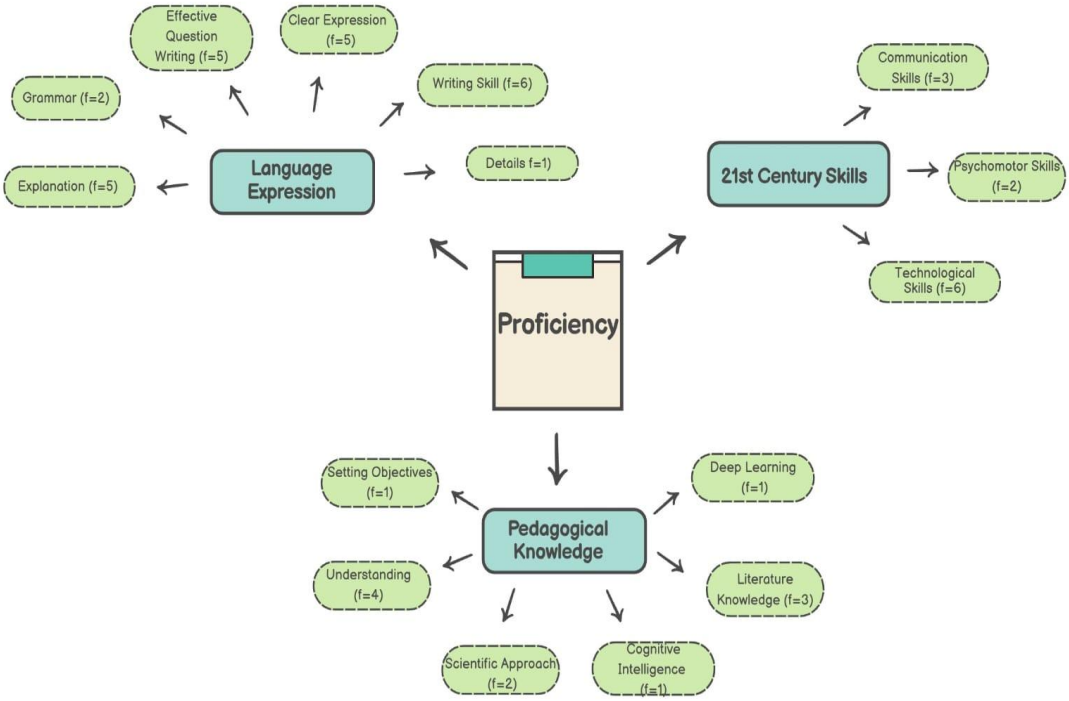

Figure 5. Skill Development to Enhance the Prompt Writing Process

An examination of the findings presented in Figure 5 reveals that the skill and knowledge levels possessed by teacher candidates play a critical role in their interactions with artificial intelligence (AI). The findings are categorized under two main headings: skills and others. Within these categories, four primary themes "language and expression," "21st-century skills," "knowledge," and "others" along with several sub-themes, have emerged. Participants emphasized that the quality of outputs obtained from AI is largely determined by their own linguistic competencies. Among the most frequently highlighted sub-themes were writing skills (f=6), technological skills (f=6), effective question formulation and writing (f=5), clarity of expression (f=5), and explanation (f=5). Additionally, issues such as grammatical accuracy (f=2) and insufficient detail (f=1) were also noted. Within the scope of 21st-century skills, user-related competencies such as technological skills (f=5), communication skills (f=3), goal-setting (f=3), scientific approach (f=2), and psychomotor skills (f=2) were identified as decisive factors in the AI usage process. Furthermore, under the "others" category, higher-order thinking skills including comprehension (f=4), reading (f=3), deep learning (f=1), and procedural intelligence (f=1) were emphasized as important. Regarding the theme of knowledge, participants expressed the need for formal instruction (f=6) and the integration of curiosity driven information into AI systems (f=1). The prevalence of calls for instructional interventions underlines teacher candidates' perception of a knowledge gap in AI-based applications, which they expect to be directly addressed through education. Overall, the findings suggest that teacher candidates need to develop multifaceted competencies linguistic, technological, cognitive, and pedagogical to use AI effectively.

Selected exemplar statements from the participants are presented below:

> *T-4: Strategic thinking, deep learning, and procedural intelligence should be developed to be more adaptive and constructive. T-16: Training on AI usage can be provided to education faculty students to foster effective prompt writing skills and AI utilization. T-18: Skills such as questioning, self-expression, comprehension, and understanding need to be developed, since obtaining the desired information from AI begins with asking the right questions. T-24: Proficiency in using Turkish effectively should be improved. One must recognize that the interlocutor's understanding may differ from their own; therefore, expressing oneself as clearly and plainly as possible is essential. T-26: I have no opinion. T-27: Effectively using AI-supported educational tools. T-31: AI support should be incorporated into the curriculum to enhance effective utilization.*

Finally, the study aimed to evaluate pre-service science teachers' recommendations for enhancing the efficiency of prompt writing in artificial intelligence applications. The findings obtained are presented in Figure 6.

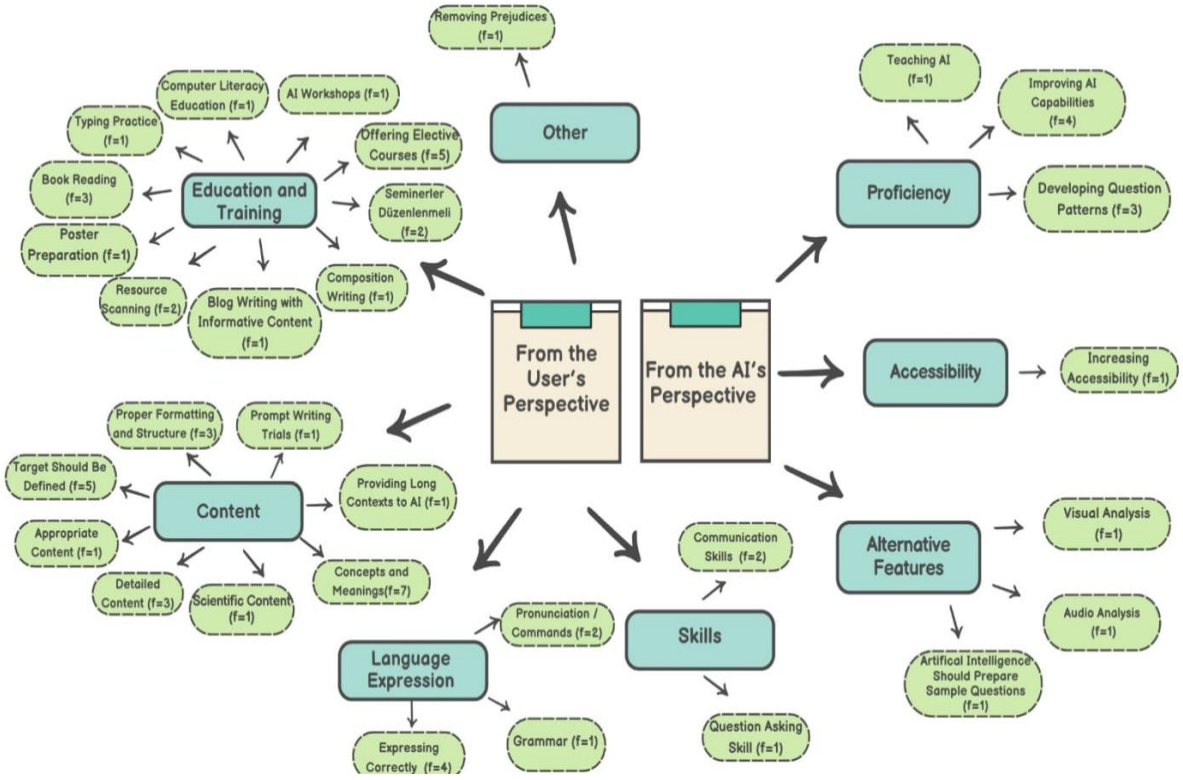

Figure 6. Recommendations for Enhancing the Effectiveness of Prompt Writing in AI Applications

An analysis of the findings presented in Figure 5 indicates that the experiences encountered in using artificial intelligence are evaluated by pre-service science teachers within two categories: "user-related" and "artificial intelligence-related." Challenges experienced from the user perspective are grouped under the themes of education and training, language and expression, content, skills, and others. Within the education and training theme, the most frequently reported problem was inadequate responses (f=15), while issues such as lack of clarity regarding the objective (f=3), deviation from the objective (f=1), misdefinition of the topic (f=2), inability to provide detailed responses (f=1), misunderstanding of similar words (f=1), inability to follow chronological order (f=1), lack of

contextualization (f=2), ethical concerns (f=1), and deficits in critical thinking skills (f=1) emerged as both content-related and cognitive-level challenges. Regarding the content theme, difficulties related to linguistic competencies were observed, including insufficient detail (f=5), incorrect content (f=2), incomplete writing (f=2), unclear explanations (f=2), misconceptions (f=1), complex information (f=2), grammatical usage (f=1), and sentence formation problems (f=1). Additionally, the language and expression theme revealed problems such as inaccurate expression (f=4) and lack of pronunciation/command clarity (f=2). Under the skills theme, inadequacies in question-asking skills (f=1) and communication skills (f=2) highlighted interaction difficulties faced by users. The "others" category drew attention to individual deficiencies affecting the process, such as correct question formulation (f=1), which could not be classified directly under other themes. From the perspective of artificial intelligence, the themes identified include competence, accessibility, and alternative features. Under the competence theme, participants indicated that AI is open to development, emphasizing that AI can be improved (f=4), should enhance its question patterns (f=3), and can be taught (f=1). Within the accessibility theme, suggestions were made to increase accessibility (f=1). The alternative features theme revealed expectations for AI to provide not only written responses but also multimodal support, including recommendations such as visual analysis (f=1), voice analysis (f=1), and example question provision (f=1). Taken together, these findings suggest that teacher candidates experience various challenges in AI use stemming from both their own competencies and the technological limitations of the tools, while simultaneously demonstrating an awareness of the system's potential for improvement. Selected participant statements are presented below:

> *T-1: Organizing seminars, offering elective courses, or preparing informational blog posts would be effective on this matter. T-5: If we want, for example, a summary of a piece of information from AI, providing it first with detailed information to summarize yields more efficient results. Therefore, AI should learn from us and interpret accordingly. T-8: Questions posed to AI should be scientifically robust. T-9: AI workshops are important because detailed learning can take place. Composition writing is essential since the more fluent and detailed our inputs to AI, the better the responses we receive. T-12: We must pay attention to spelling and punctuation and write sentences properly. T-22: Providing AI with appropriate content is crucial because writing the requested expression accurately is an important task. T-30: Objectives should be clearly defined and stated.*

Discussion

This study offers significant insights into pre-service science teachers' perceptions and experiences regarding the prompt writing process within AI-supported educational settings. The findings highlight that participants view prompt quality as a critical skill for engaging effectively with AI tools. The first major result reveals that the majority of candidates acknowledge the importance of prompt writing, evaluated from two primary perspectives: that of the user and that of the AI system. This aligns with previous research by Zhou (2023) and Huang (2025), who emphasized the necessity of effective human AI interaction to maximize educational outcomes. Participants indicated the need to develop multidimensional competencies linguistic, cognitive, pedagogical, and technological to communicate effectively with AI systems. Moreover, the prompt writing process was perceived not simply as a technical task, but as one requiring higher-order skills such as critical thinking, inquiry, and content creation. Consistent with this, Woo et al. (2024) found that university students' prompt writing abilities and AI self-efficacy

significantly improved through structured interventions. Additionally, a comprehensive literature review by Sahoo et al. (2024) demonstrated that the quality of AI outputs largely depends on the clarity, scope, and contextual framing of user inputs. Thus, prompt writing is better understood as a holistic process that integrates cognitive reasoning, question generation, and narrative construction. Supporting this view, Chen et al. (2020) reported that employing AI tools with well-designed techniques enhances students' cognitive flexibility, adaptability, and problem-solving capacities.

Findings related to the key elements of effective prompt writing indicate that participants emphasized the use of clear and comprehensible language, adherence to writing conventions, and the necessity of specificity in relation to the subject matter. These findings align with studies such as Chen et al. (2024), which underscore the impact of prompt quality on the relevance and accuracy of AI-generated outputs. Participants' awareness of concepts like "topic–purpose alignment" and "providing prior knowledge" further highlights the importance of pedagogical design thinking in human–AI interactions. Notably, instances in which participants struggled to clearly articulate their questions, inadequately specified their intentions, or received unsatisfactory AI responses point to competency gaps not only in technological proficiency but also in cognitive and linguistic dimensions. Laupichler et al. (2022) conceptualize AI literacy as more than the mere technical use of tools; it encompasses a multidimensional skill set involving critical evaluation, analysis of outputs, and the cultivation of ethical awareness. These findings suggest that teacher education programs should go beyond simply introducing digital tools and instead foster the ability to interact with such technologies critically, reflectively, and responsibly.

The challenges reported by participants indicate that prompt writing is not merely a technical task but a complex, multidimensional process encompassing cognitive, linguistic, and ethical considerations. Among the most frequently cited difficulties were the inability to articulate queries clearly and the failure to define objectives explicitly—both of which suggest limitations in cognitive load management and metacognitive awareness. These findings align with prior research indicating that effective interaction with artificial intelligence is closely tied to individuals' cognitive competencies (Tan et al., 2025). Giray (2023) also emphasized that inadequately constructed prompts can lead to various issues in AI outputs, such as inaccuracies and ambiguity. Consequently, prompt engineering is increasingly recognized as a vital skill for both students and graduates entering AI-integrated professional environments (Lee & Palmer, 2025; Raftery, 2023).

Pre-service science teachers highlight the necessity for structured training in areas such as written communication, technological proficiency, strategic thinking, and question formulation to develop effective prompt-writing skills in AI tools. As artificial intelligence becomes increasingly embedded in educational settings, the ability to engage with and guide AI processes is emerging as a key competency for contemporary educators (Foster & Piacentini, 2023). Lee and Palmer (2025) argue that prompt engineering should be regarded as a core competency rather than an optional skill at the higher education level. Moreover, integrating GenAI into creative curricula can enhance students' understanding of how such tools influence the quality and innovation of AI-generated outputs. In this regard, prompt design is not merely a technical skill but also a pedagogical element that should be embedded into teacher education programs. Indeed, a review of recent studies suggests that prompt engineering is increasingly conceptualized as a developing skill set that must be explicitly taught (Aaron et al., 2024; Zawacki-Richter, 2024).

Another noteworthy insight from participants is their recognition of AI's open-ended nature, along with suggestions for improving its responsiveness—such as incorporating multimodal outputs like visual or auditory feedback. This perspective illustrates that pre-service teachers view AI not only as a utilitarian tool but also as a technology open to critical reflection and iterative enhancement (Southworth et al., 2023). In doing so, they position themselves not as passive users but as active stakeholders capable of reshaping AI-enhanced learning environments.

Pre-service science teachers underscore the necessity of structured training in key areas such as written communication skills, technological proficiency, strategic thinking, and question formulation to improve the effectiveness of prompt writing in AI tools. As artificial intelligence becomes increasingly integrated into educational settings, the capacity to interact efficiently with these tools and to effectively manage this process has emerged as a critical contemporary competency for teachers (Foster & Piacentini, 2023). Lee and Palmer (2025) further contend that prompt engineering should be considered a core competency within higher education curricula rather than an elective. Additionally, a thoughtfully designed curriculum that instructs students on how to incorporate generative AI (GenAI) into creative processes can enhance their understanding of the impact AI-generated outputs have on both quality and innovation. Within this context, prompt design is regarded not merely as a technical skill but as a pedagogical component that must be integrated into teacher education programs.

A comprehensive review of the literature indicates that prompt engineering is increasingly recognized as an essential and emerging skill set that should be integrated into student curricula (Aaron et al., 2024; Zawacki-Richter, 2024). Moreover, participants in this study demonstrated an acute awareness of the evolving nature of artificial intelligence and advocated for system enhancements, including improved feedback mechanisms and the incorporation of multiple response modalities, such as visual and auditory analyses. This outlook suggests that pre-service teachers regard AI not merely as a tool for user interaction but as a dynamic technology open to critical evaluation and continuous improvement (Southworth et al., 2023). Accordingly, pre-service teachers move beyond passive users to become active agents capable of transforming AI-supported educational environments.

Conclusion

This study examined the perspectives of pre-service science teachers on prompt writing within AI-supported instructional processes, revealing important insights related to both individual competencies and systemic requirements. The findings suggest that teacher candidates need to cultivate multidimensional skills including linguistic, cognitive, pedagogical, and technological competencies to engage effectively with artificial intelligence. Moreover, prompt writing is identified not merely as a technical activity but as a complex process that entails higher-order skills such as critical thinking, inquiry, and content creation.

Recommendations

Based on these results, it is recommended that teacher education curricula be revised to incorporate structured courses and practical experiences focusing on AI literacy, effective question formulation, critical thinking, and

ethical awareness. Additionally, the development of comprehensive guidance materials on classroom integration of AI applications and the establishment of hands on training opportunities such as workshops and laboratory sessions tailored to instructional technology courses are essential. This study further emphasizes that pre-service teachers should move beyond passive use of AI tools to assume active roles as content creators, critical interrogators, and developers. These findings highlight the urgent need to realign teacher education programs with the evolving demands of the digital era.

Limitations of the Study

This study is limited to the perspectives of pre-service science teachers enrolled at a single university, and therefore, the findings may not be generalizable to other disciplines or socio-cultural contexts. While the structured interview form used for data collection provided valuable qualitative insights, it may have restricted the depth and richness of participants' experiences. Furthermore, the AI tools utilized in the study likely varied in terms of model architecture, language capabilities, and response algorithms, potentially affecting the consistency of user experiences. Considering the rapid pace of AI technological advancements, the relevance and applicability of these findings may be time-sensitive. Accordingly, future research is encouraged to include more diverse participant samples, employ multiple data collection methods, and focus on specific AI platforms to enhance generalizability and validity.

Statements and Declarations

Ethics Approval and Consent to Participate: All of the procedures performed in studies involving human participants were in accordance with the ethical standards and the Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent: Informed consent was obtained from all participants (prospective science teachers) prior to data collection.

Statement Regarding Research Involving Human Participants and/or Animals: This research involved human participants (prospective science teachers). All procedures were conducted in accordance with ethical standards, and written informed consent was obtained from all participants.

Consent to Participate: All participants provided written consent to participate in the study.

Consent to Publish: Consent to publish the findings of the study was obtained from all participants.

Funding: Not applicable.

Financial Interests: The authors declare they have no financial interests.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: All authors contributed to the data collection, analysis, and writing of the paper. All authors read and approved the final manuscript.

Non-financial Interests: None.

Data Availability Statement: Research data associated with the paper is available upon request.

Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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