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Utilization of AI-Driven Smart Prompts in Academic Research in Higher Education Institutions

Marchee T. Picardal*
Cebu Normal University – Balamban Campus
Cebu City, Philippines
University of the Philippines Los Baños, College of Development Communication, Laguna, Philippines

Abstract. This study investigates how preservice science teachers utilize AI-driven smart prompts to support academic research writing within a digitally mediated learning environment. It explored not only the AI tools used but also the specific aspects of prompt use, including their structure and their functions. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, the research employs a qualitative descriptive design to investigate the interactive processes and pedagogical implications of integrating AI. Data were gathered from 65 preservice science teachers (BSED Science) through AI interaction logs, guided reflections, interviews, and research output assessments. Results highlight that AI tools, most notably ChatGPT, Perplexity AI, and Gemini, were extensively used for content generation, methodological guidance, data interpretation, and refining academic language. The study identified diverse prompting strategies (e.g., contextual, iterative, role-based) and mapped seven contextual factors influencing AI use. While AI served as a cognitive and metacognitive scaffold, concerns emerged regarding over-reliance, academic integrity, and the need for critical oversight. Findings underscore the importance of embedding AI literacy and smart prompt engineering into preservice teacher education to promote responsible, student-centered engagement with emerging technologies. The study contributes to the discourse on how AI-mediated learning can transform instructional design and assessment in science education.

Keywords: smart prompts; preservice teachers; academic writing; TPACK; AI in Education

*Corresponding author: Marchee T. Picardal; *picardalm@cnu.edu.ph*

1. Introduction

The rise of the 4th Industrial Revolution has expanded the definition of "artificial intelligence to intelligent systems capable of performing complicated functions and intellectual tasks (Hodgson et al., 2022). With recent emerging configurations and various applications, the definition evolved into a "computing system that can engage in human-like processes such as learning, adapting, synthesizing, self-correction, and the use of data for complex processing tasks (Popenici & Kerr, 2017, p.2). Though it gained scholars' attention in the past 30 years (Luckin et al., 2016), Artificial Intelligence in Education (AIEd) has generally been recognized as a transformative force in education in the last decade (Crompton et al., 2024).

A complex phenomenon involving the relationships between technology, pedagogy, and content, generative AI (GenAI), a type of AI driven by machine learning models, has emerged recently. It has demonstrated numerous opportunities, affordances, and challenges in improving teaching and learning through the creation of content (Petko et al., 2025). Amidst the fear of the impact of AI, Cope et al (2021) reassured that it will never in any sense "take over" the role of teacher, because how it works and what it does are so profoundly different from human intelligence.

However, it offers the potential to transform education in ways that can make education more human, not less. Crompton et al. (2021) conducted a systematic review of 169 AI research published from 2011 to 2021 to examine how AI is used to support teaching and learning in K-12 education. They found that AIEd was used to enhance pedagogies, administration, and subject content. Narrowing down in the field of science education, Heeg & Avraamidou (2023) systematically reviewed studies that utilized AI in this field from 2011 to 2021 and revealed nine different types of AI applications: automated assessment, automated feedback, learning analytics, adaptive learning systems, intelligent tutoring systems, multilabel text classification, chatbot, expert systems, and mind wandering detection.

Several other uses of AI in Education varied in purpose. Recent empirical-driven research on AI in Education (AIEd) includes its application to support personalized professional development through automated analysis of classroom interactions and tailored feedback using AI-generated instructional videos (Pallas, 2025). It was reported to promote positive learning outcomes, and such materials can effectively enhance knowledge retention, transfer, and self-efficacy, positioning them as promising assets in science teacher education.

There remains a gap in understanding AI's collective educational affordances and challenges across different levels and disciplines (Zawacki-Richter et al., 2019), with many scholars unanimously calling for a great deal of studies to be done on it. Choung et al (2023) attributed the users' trust and intention to use AI technologies to the human-like and functionality. However, interestingly, despite the popularity of AIEd and its perceived beneficial effects to learning, there remains a documented negative teacher perception of technologies (Wang & Fan, 2025) leading to some of them who will not use it at all or use it negatively to put

AI in bad light (Crompton & Burke, 2023). The lack of understanding of teachers may be due to their limited technological skills, particularly when they are unfamiliar with using AI in teaching and learning. Recently, Petko et al. (2025) enhanced their professional development framework (TPACK) to support good integration practices of technology such as AIEd. The kinds of expertise teachers need to use these technologies efficiently. They maintained that a more comprehensive definition of contextual knowledge (XK) should take into account how it will affect people, society, and ultimately the larger educational context, in addition to the local environment. There is much ambiguity surrounding the implications of these technologies for student learning, teacher practice, and teacher education.

According to the updated TPACK framework (Petko et al., 2025), teachers require particular kinds of knowledge to use technology in their lessons creatively and efficiently. With the emergence of AIEd, educational systems face new problems and important concerns about what learning is and what modern teachers need to know to succeed, particularly how to incorporate AIEd tools into their lessons best. With the rapid growth of AIEd, there is a need to reconsider the effectiveness of existing professional development to prepare educators for the relevant competencies of integrating AI technologies in the teaching and learning processes and systems (Ren & Wu, 2025; Petko et al., 2025) which could disrupt the interaction of technology, pedagogy, and content affecting the quality of instructional delivery and learning outcomes (Wang & Wang, 2022). Only when teachers have sufficient knowledge and training can they maximize and tap the educational affordances of AI (Algerafi et al., 2023; Bhimdiwala et al., 2022).

2. Review of Related Literature

2.1 On the effect of AI on teachers' Research Skills

Artificial Intelligence (AI) has revolutionized teacher training in general and in academic writing in particular, preparing them for the 21st-century classroom (Anderson et al., 2025). Research indicates that teacher acceptance of AI tools in education is increasing, particularly among tech-savvy preservice teachers due to their perceived usefulness and ease of AI tool integration (Ma & Lei, 2024) expecting them to integrate AI-powered research tools into their classrooms (Ng et al., 2024) as well as in the curriculum design (Fullan et al., 2024). AI-driven platforms like ChatGPT, Google Bard, and educational chatbots are used popularly to personalize learning experiences, provide instant feedback, and foster critical thinking (Holmes et al., 2019).

One of the most promising applications of AI in this field is the use of smart prompts, which guide preservice teachers in structuring research, inquiry-based learning, and instructional design. Recent studies support the need to examine research writing skills among preservice teachers, as Talavera-Mendoza et al. (2024) deduced that both inservice and preservice teachers are adopting an inquiry approach to science teaching. Specifically, higher-order thinking areas of conceptualization, data analysis, and critical thinking benefit from this technology (Wang & Fan, 2025) by assisting students in identifying research gaps, structuring proposals, and synthesizing findings (Johnson et al., 2025). Moreover, AI-

powered systems can analyze large datasets quickly, enabling students to focus on interpreting results and drawing meaningful conclusions (Chen et al., 2023). For preservice teachers, the integration of AI in research courses fosters not only technical proficiency but also the capacity to innovate in addressing educational challenges. However, caution is needed against over-reliance on AI tools, emphasizing the need for students to maintain academic integrity and develop independent critical thinking skills (Fui-Hoon Nah et al., 2023).

2.2 Use of AI and Smart Prompts

Smart prompts refer to the thoughtfully crafted inputs by the user designed to guide AI responses. It plays a critical role in enhancing learning outcomes. They stimulate higher-order thinking by encouraging learners to ask meaningful questions, refine their ideas, and explore alternative perspectives (Yang et al., 2023). In academic research writing, prompts serve as scaffolds that guide students through complex tasks such as formulating research questions, conducting literature reviews, and interpreting data (Wang & Siau, 2022). The quality of these prompts directly influences the depth and relevance of AI-generated responses, highlighting the importance of teaching students how to craft effective queries (Zhang, 2021). For preservice science teachers, mastering the art of smart prompting aligns with inquiry-based learning goals, which emphasize exploration, reflection, and evidence-based reasoning, fostering student agency (Yang et al., 2024; Cotiangco et al., 2024).

This skill helps learners move from surface to deep learning through guided questioning and iterative feedback, as it offers personalized knowledge scaffolding by refining their research questions and methodology in real time (Crompton et al., 2024). Despite its advantages and benefits, one drawback is the tendency of the user to have limited independent critical thinking and limited use of higher-order thinking skills (Essien et al., 2024) and superficial learning experiences rather than deep understanding (Nemorin et al., 2023).

Based on the Artificial Intelligence Anxiety Scale, educators with low AI literacy often perceive AI as a threat rather than a pedagogical aid (Wang & Wang, 2022), and those with low trust resist AI-driven assessments and smart prompts (Yilmaz et al., 2024). AI-powered smart prompts also have biases in their results, with an inclination to Western epistemologies and studies, marginalizing alternative perspectives in scientific inquiry (Pradana et al., 2023). Another recurring issue is the lack of training in effectively utilizing AI tools, resulting in superficial interactions and limited learning gains (Huang & Chien, 2022).

Additionally, ethical concerns arise regarding data privacy, plagiarism, and the potential for AI to generate biased or inaccurate information (Kong et al., 2022), probably due to hallucination, a weakness of AI (Alkaissi & McFarlane, 2023). Additionally, AI literacy training should be embedded in teacher education programs, ensuring that preservice teachers develop metacognitive awareness of AI's affordances and limitations (Chiu et al., 2024). For preservice teachers, understanding these ethical considerations is essential to ensure the responsible use of AI in both their academic work and future classrooms (Picardal, 2025).

Educators play a critical role in teaching students to critically evaluate AI-generated content and balance its use with traditional research methodologies (Kumar, 2023). Farazouli et al. (2024) found that AI-driven plagiarism detection tools improve research transparency and academic honesty, helping preservice teachers refine their writing while maintaining ethical standards. Additionally, Ng et al. (2024) highlighted that AI-powered feedback mechanisms encourage self-regulation in research writing, fostering independent learning and academic integrity. Complementing this knowledge co-creation strategy with the traditional research instructional approach can minimize those risks and biases, which this study is the first to document and report.

2.3 Research in Context

Students' perceptions of technology also have a significant influence on their learning behaviors and experiences (Ren & Wu, 2025). In the context of teacher training institutions, preservice teachers need to take up research courses in their degree program as part of their professional and personal development to be successful reflective practitioners in the field (Picardal & Sanchez, 2022). With the rising trend of incorporating AI in higher education, many researchers have investigated students' perceptions and experiences in AI-aided learning contexts (Barrett & Pack, 2023). In this context, the use of AI in an academic writing course is the context of the current investigation. Several studies explored the use of AI in academic writing to improve their language acquisition, ideation, expression, and communication (Li et al., 2021) and performing various tasks in learning, research, and working contexts, as indicated in brainstorming, personalization, accessibility, and support services (Chan & Hu, 2023). AIEd also promoted students' learning motivation, self-efficacy, and achievement (Li et al., 2021).

Research findings indicated the challenges and limitations of integrating AI in higher education, with algorithmic biases and a lack of transparency in decision-making as one of those (Bhimdiwala et al., 2022; Celik, 2023). This scenario prompts educators to critically evaluate AI tools and promote the inclusiveness and transparency of learning environments (Ren & Wu, 2025). Yang & Chen (2023) pointed out that educational chatbots are seen as the future of technology integration in the field of education. More research is required to better define students' experiences and attitudes toward AI technologies for successful integration in teaching and learning, given the research gap in examining students' perceptions of using these technologies in higher Education (Chan & Hu, 2023).

Understanding teachers' experiences and perceptions on using chatbots during their preservice training may help uncover additional directions for enhancing the development of educational chatbots and other AIEd (Papadakis et al., 2021; Huang & Qiao, 2024). Considering that the preservice training is transformative to the teachers' beliefs regarding AIEd efficacy, this study is highly relevant and novel, as their familiarity with and beliefs about instructional technology significantly depend on their preservice learning experiences. Thus, vital for preparing students for a technology-centric future (Ding et al., 2024). However, these teachers are unfamiliar with many of these AI tools. They could lack the in-

depth technical know-how to employ AI educational apps to help them educate, let alone help students build their digital AI skills. As a result, to employ and instruct AI in their classrooms, educators must increasingly arm themselves with sufficient digital capabilities (Ng et al., 2023). Hence, this study examines the prompts preservice teachers feed into the chatbot in their academic writing journey, a critical component of higher education training.

2.4 Research Objectives

This study generally aimed to examine the nature and quality of smart prompts utilized by preservice science teachers when interacting with AI in conceptualizing and writing their research in a science teaching course. Specifically, it seeks to:

1. Identify the different AI tools in education that students utilize in the research writing process.
2. Analyze the nature, structure, and purposes of the smart prompts that students employed during their academic research writing.
3. examine the aspects of AI-prompt used during academic research writing; and
4. Determine the contextual factors influencing students' decision-making to utilize AI in their research writing

3. Research Methodology

3.1 Research Design

This study employed a qualitative descriptive design, which is particularly appropriate because the aim was to provide a comprehensive, straightforward description of preservice teachers' actual practices and experiences with AI-driven smart prompts. This design focuses on summarizing events and experiences in participants' terms (Sandelowski, 2000), allowing the researcher to stay close to the data, offering a rich, low-inference account of participants' perspectives and behaviors. Specifically, this design was suited to documenting the nature, structure, and purposes of prompts and the contextual factors influencing their use, without imposing heavy theoretical abstraction. Following the protocol outlined by Sandelowski (2000) and later elaborated by Colorafi & Evans (2016), this study observed the protocols' rigor by using multiple data sources (AI interaction logs, interviews, reflections, and research outputs) to capture a holistic description.

Anchored on the updated TPACK framework (Petko et al., 2025), the study design emphasized the interplay of technological, pedagogical, and content knowledge in preservice teachers' use of AI-driven prompts. This framework informed the study in three ways: (a) in study design, it guided the focus on how AI functions as a technological scaffold to support pedagogical reasoning in research conceptualization and writing; (b) in data collection, it shaped the choice of multiple sources (AI interaction logs, reflections, interviews, and outputs) to capture how technology, pedagogy, and content intersect in authentic student practices; and (c) in data analysis, it provided a lens to interpret how prompts mediated not only technical tasks (e.g., generating text, refining grammar) but also pedagogical purposes (e.g., clarifying research methods, supporting inquiry-based learning, scaffolding higher-order thinking).

3.2 Research Environment

The study was conducted in a teacher training institution located in Central Visayas, Philippines. The university has no defined institutional policy yet on the use of AI in instruction and research. This study is deemed necessary as globally, there is a massive, urgent call for guidelines on how and when to use AI, particularly in the academe appropriately, and contextually, it offers recommendations for the institutional guidelines. Spivakovsky et al (2023) emphasized that the development of institutional policies in higher education institutions should focus on the scope of AI applications, which will allow the academic community to determine the appropriate scope of AI applications in the educational process and prevent the use of AI in areas where ethical norms are violated.

AI integration in academic settings ensures that stakeholders are aware of their responsibilities and can take appropriate actions accordingly (Chan, 2023). Since the pandemic, blended learning modalities have been utilized in terms of instructional delivery, supporting technology-integrated instruction.

3.3 Research Instruments

This study involved multiple data sources that aimed to enhance the credibility of data and conclusion (Sandelowski, 2000). The first document source was the interaction logs that refer to the printed copy of the interaction (a) chat proceedings containing the smart prompts and responses, and (b) the research outputs of students with their preferred AI tools (i.e., ChatGPT, Perplexity, etc) to examine the nature and quality of inputs with the AI-aided contents. The second instrument was the interview guide, which consisted of 5 open-ended questions focusing on the experiences, challenges encountered, and reasons for using AI in their research course.

3.4 Research Respondents and Sampling Procedure

There were 85 students enrolled in the course; however, only 65 voluntarily participated and reported using AI tools in their research work. Therefore, there were 65 artifacts collected on the nature and process of interaction with the various AI tools used. These students were grouped according to their research area of interest, leading to 15 groups representing 15 research papers. To triangulate the processes and learning outcomes of the students, a one-on-one interview was employed to select a representative of the group (n=15).

Students were asked to write down their experiences and perspectives on the use of AI in their academic writing, particularly for the course requirements of developing, implementing, and completing a research paper through a reflection log. Considerations in the selection of participants for the interview were the following: their use of AI tools for research-related tasks, their willingness to provide the AI interaction logs, and their participation in the interviews. This purposive sampling ensured diverse perspectives on how students use and experience AI in their educational research course.

3.5 Data Gathering Procedure

At the start of the semester, the teacher-researcher briefed the students to explain the study's purpose, procedures, and ethical considerations. Right after the researcher secured the informed consent. Part of the course orientation was on the instructional delivery modality (75% onsite and 25% online), hence the use of technology-mediated instruction. Students have the freedom to utilize whatever learning tools they perceive as helpful in their learning. A 50-item objective-type diagnostic test consisting of the educational research concepts, methods, and processes was used to assess their research knowledge and skills.

During the first week of the course delivery, students were grouped accordingly based on the result of the diagnostic test, where the high scorers were merged with the average and low-scoring students to ensure that there is no disadvantaged group in terms of progress and output submission. Students were free to select the research area of interest as long as it aligned with their degree program and was responsive to the priority agenda of the Department of Education (DepEd) or the Commission on Higher Education (CHED).

At this point, students started to conceptualize their research focus by search-engine aided literature scanning, such as from Google or Google Scholar, read national agency reports, did their library work, and conducted interviews with school administrators on their perceived problems and potential solutions to the problems. Students then submitted their proposed research area for approval and were advised to narrow down to a potential research topic through an extensive literature review. This process is where the use of AI tools came into play. Considering that these AI tools are freely available, they were instructed to document their search process, including the prompts they keyed in and the responses they received, to expound their understanding of their research topic.

Throughout the course, students must maintain a log of their interaction with different apps and AI tools that aid in their research work. The researcher ran all students' outputs via Turnitin software for plagiarism detection, as well as to ensure AI detection at 20% only. The course was divided into two parts: midterm (research proposal presentation) and final term (completed research presentation). In both periods, the researcher conducted a one-on-one interview with select participants to gain insights into their experiences, perceptions, and reflections on their research journey, particularly with the use of AI tools. At the end of the semester, the interaction logs, their reflection papers, and students' final research papers that were independently rated by two external panelists using the rubric were collected to determine the influence of AI on their research competencies.

3.6 Data Analysis

The data analysis adhered to the qualitative descriptive design protocol (Sandelowski, 2000; Colorafi & Evans, 2016), complemented by Braun and Clarke's (2023) thematic analysis framework to systematically identify and organize patterns across the data. This approach was appropriate because it allowed the study to remain low-inference and descriptive while producing a structured account of participants' prompt use and contextual experiences. The

thematic analysis process began with familiarization, where AI interaction logs, reflection papers, and interview transcripts were repeatedly read to achieve immersion. In the coding phase, meaningful data segments were systematically coded (e.g., "grammar support," "conceptual scaffolding," "time pressure," "feedback seeking"), staying close to participants' language. These codes were then collated into candidate themes such as "functions of prompt use" or "contextual challenges."

In the reviewing themes phase, the researchers compared the codes and candidate themes across data sources (interaction logs, interviews, and reflections) to ensure consistency and triangulation. The defining and naming themes phase refined these categories into coherent, descriptive themes aligned with the research questions (e.g., "AI as a cognitive scaffold," "AI for language refinement," "contextual drivers of AI reliance"). Finally, in the reporting phase, illustrative quotes and examples reflected participants' accounts presented the findings.

Consistent with the qualitative descriptive tradition, analysis prioritized presenting participants' experiences in their terms rather than imposing abstract theorizing. To enhance credibility and dependability, multiple members of the research team cross-checked coding and resolved discrepancies through discussion. This process produced a robust, transparent account of how preservice teachers employed AI-driven smart prompts in their research writing and the contextual factors shaping this practice.

3.7 Ethical Considerations

All respondents were provided written consent before participating, and they had the right to withdraw at any time without penalty. Data collected, including AI interaction logs and student outputs, was kept confidential to protect their identity. Participation was entirely voluntary, with no academic penalties or incentives tied to involvement in the study. The students were reminded of ethical guidelines for using AI in academic work, including proper attribution, and the transparency of their AI use would not affect their grades.

4. Results

The findings in this study provided rich insights into the nature, purpose, and structural strategies of AI tool utilization in academic research writing among preservice science teachers, which can potentially enhance their research competencies necessary in the profession as reflective practitioners in the field.

Table 1: AI tools in education that students use in the research writing process

AI tools	*Function/Specialization	f	%
CHATGPT (OpenAI)	A conversational AI chatbot specializes in generating human-like text, answering questions, tutoring, writing, summarizing, and assisting in content creation across a wide range of topics.	40	62%
Perplexity AI	A conversational search engine that uses large language models to give fact-based answers with real-time citations from the web.	21	32%
*Gemini	Google's AI model (formerly Bard) is integrated with Google Search and Workspace. Useful for generating content, code, and data summaries, and directly integrated into Google Docs, Sheets, etc.	11	17%
Unriddle	An AI tool focused on summarizing long content like documents, research papers, and web articles. Known for distilling complex texts into concise, digestible explanations.	1	2%
CICI (Classroom Intelligent Companion Interface)	Often used in educational contexts, it refers to AI-powered teaching assistants or bots. Its function can vary, but generally supports interactive learning, tutoring, and student engagement.	1	2%
Microsoft Copilot	An AI assistant built into Microsoft 365 apps (Word, Excel, PowerPoint, etc.) to help users generate text, summarize content, analyze data, and automate tasks.	1	2%
Quillbot	A paraphrasing and grammar-enhancement tool. Helps reword, simplify, or expand sentences, check grammar, and improve writing fluency.	1	2%
Grammarly	A real-time writing assistant that focuses on grammar, spelling, punctuation, tone, and style. Also provides clarity suggestions and plagiarism detection.	1	2%
*Google Assistant	A voice-activated virtual assistant that handles tasks like searching, scheduling, reminders, smart home control, and basic information queries. Focuses on real-time task automation and voice interface.	1	2%
Scribbr	Academic writing support tool specializing in plagiarism checks, proofreading, and citation generation.	1	2%

** Denotes that OpenAI ChatGPT provided this information to describe the functions and characteristics in the context of education.*

The data revealed that ChatGPT (62%) is the most widely used AI tool among students, followed by Perplexity AI (32%) and Gemini (17%). These tools were primarily used for content generation, tutoring, and writing assistance. This trend

supports findings of Holmes et al. (2022) and Johnson et al. (2021) that AI chatbots and writing assistants personalize learning experiences and foster critical thinking in academic writing tasks. The dominant preference for ChatGPT (OpenAI) could be due to its versatility in handling multi-step research queries and language-enhancement tasks (Ng et al., 2024). Additionally, Perplexity AI responds to the students' need for source-backed, real-time answers, considering the fast-paced nature of academic demands and schedules of university students who prefer alternative resources (Chen et al., 2023). Meanwhile, tools like Grammarly and Quillbot, though less frequently used, served critical roles in supporting language precision and academic tone, which is popular as English. However, it is the medium of instruction in the Philippines, and it is a second language for Filipino learners. However, this practice, while advantageous to students, requires ethical use to ensure academic integrity and research rigor (Cotton et al., 2024).

All 65 AI interaction logs and interview responses revealed eight key purposes for which AI tools were employed (Table 2). Foremost among these were content generation (19%), data analysis and interpretation (17%), and methodological guidance (14%). This method triangulates with the literature on the scaffolding role of AI in supporting students during the most cognitively demanding aspects of research writing (Yang et al., 2023; Wang & Huang, 2025). For preservice science teachers, this academic support is critical as they grapple with conceptualizing and executing interdisciplinary research in a field that demands both scientific accuracy and pedagogical clarity (Koumi, 2013).

The use of AI for tutoring, feedback, and presentation preparation also indicates the tool's integration across the entire research process from ideation to research presentation. Moreover, the data suggested that students recognized the adaptive capacity of AI tools to provide just-in-time assistance in areas where formal instruction may be lacking or insufficient (Crompton et al., 2022), especially in the context of blended/flexible learning modalities.

Table 2: The nature and purpose of the smart prompts that students used for their research

Purpose of AI use	AI tools	f	%
1. content generation (e.g., SOP, RRL, Abstract)	ChatGPT, Gemini, Perplexity, CiCi	38	19
2. data analysis and interpretation	ChatGPT, Gemini, Perplexity, Google Assistant	34	17
3. research design and methodology	ChatGPT, Gemini, Perplexity	28	14
4. language support (e.g., grammar, paraphrasing, clarity)	ChatGPT, Gemini, Perplexity	26	13
5. tutoring/clarification/concept building	ChatGPT, Perplexity, Gemini, Google Assistant	24	12
6. assessment and writing feedback	ChatGPT, Scribbr, Microsoft Copilot	21	11
7. citation and source retrieval	Perplexity, Scribbr, ChatGPT	15	8
8. presentation assistance (e.g., PPT, defense prep)	ChatGPT, Gemini, Microsoft Copilot	12	6

Table 3 reveals that students demonstrated varying degrees of sophistication in the structure of their AI prompts. The most dominant was direct questioning (26%), followed closely by contextual prompting (23%) and file attachment with task instructions (19%). These findings underscore the critical role of prompt engineering in optimizing AI responses, as noted by Zhang et al. (2021). Smart prompting strategies reflect students' growing metacognitive awareness in leveraging AI to clarify, elaborate, and refine their academic outputs (Yang et al., 2024). Contextual prompts, those that include background information before a question, signify students' attempts to simulate human-like communication with AI, enhancing response relevance and specificity (Crompton et al., 2024).

File-based prompts also demonstrate an emerging trend in multimodal AI interaction, wherein students upload their documents for analysis, suggesting a shift from superficial querying to deeper integration into the writing workflow. Interestingly, the polite prompting is what makes this phenomenon unique as this attempts to "humanize" the interaction with AI tools which Bailey et al. (2021) and Birenbaum (2023) posited that ChatGPT for instance lacks emotional intelligence and this kind of prompting tries to establish emotional resonance Wang & Fan (2025) implying that students avoided overly mechanized interaction with these technologies.

Table 3: Structure of smart prompts that students feed to AI to generate the desired responses

Structure of smart Prompt	Nuances	f	%
direct questioning	short and straight commands ("What is the bes t theoretical framework for climate educatio n?")	51	26
contextual prompting	giving background before asking ("Our study is about climate awareness among Grade 10 students. What would be a suitable research design?")	46	23
file attachment with task instruction	Here is our RRL draft (attached). Please revise and summarize it in APA format.'	38	19
polite prompting	With greetings, 'please', 'thank you (Hi, can you help me paraphrase this paragraph? Thank you!)	28	14
iterative prompting	follow-ups, clarification requests (This abstract seems off. Can you rewrite it based on this revised version? Also, add a stronger conclusion.)	25	13
role-playing prompting	asking AI to act as a researcher or expert ("Pretend you are a research professor. How would you critique my methodology section?")	10	5

4.1 Contextual factors influencing students' decision-making to utilize AI in their research writing.

Based on the data from the narrative accounts of students during their interviews and reflection logs, several contextual factors influence their decision-making to utilize AI tools in their academic research. These factors can be grouped and thoroughly described in terms of the academic demands associated with research writing in the context of teacher education training and higher education institutions.

4.1.1 Cognitive load due to comprehension difficulties

Many students expressed that they struggled with understanding complex terminologies and processes in research (e.g., data analysis techniques, statistical tools, or theoretical frameworks), including the research topics they are working on, their jargon, and peculiarities. AI tools like ChatGPT, Perplexity, and Gemini break down these complex concepts into simpler language or define jargon. HEI students are expected to master both pedagogical theories and scientific content simultaneously, and this interdisciplinary concept requires cognitive scaffolding. Hence, the challenge of writing scientifically sound research papers can be overwhelming to them. These AI tools reduce this cognitive burden by clarifying difficult content, especially in methodology and analysis sections.

4.1.2 Time pressure and academic workload

Students frequently cited the use of AI as a time-saving measure to meet tight deadlines or manage multiple academic responsibilities (e.g., juggling class requirements, teaching demonstrations, and other field-related duties). This task includes generating drafts, summarizing long texts, or rephrasing sections of their manuscript. Notably, they claimed to have saved time through auto-generation features and their ability to synthesize information, such as in generating or refining research components (e.g., statement of the problems, rationale, abstract) without having to start from scratch.

4.1.3 Uncertainty in writing structure and format

Many used AI to seek guidance on how to structure parts of the paper (e.g., RRL, abstract, discussion). They asked for outlines or templates to model their work after. Research writing is not yet an ingrained skill for many undergraduates. Inherent to their degree program, which is in the science education field, their research topics often involve interdisciplinary ideas (biology, physics, chemistry), which may make it challenging to organize their arguments cohesively. AI provides structured guidance to ensure coherence in writing.

4.1.4 Lack of confidence in grammar and academic tone

Several students admitted they used QuillBot, Grammarly, and ChatGPT for grammar correction, paraphrasing, and improving academic tone. English writing support, especially for non-native speakers like Filipinos, serves as a second language; they may lack the proficiency to express ideas articulately and academically. Their fear of being penalized for grammatical lapses motivates them to refine their output with AI before submission.

4.1.5 Limited access to academic resources
Students relied on AI tools to generate related literature, cite sources, or provide summaries of scholarly articles, which collectively is the most daunting task for them. Tools like Perplexity and Scribbr are used to locate or distil studies when students have limited access to subscription-based journals or when studying remotely from home or workplaces, as some of them were working students. AI fills this resource gap.

4.1.6 Desire for validation and feedback
Students used AI as a sounding board to validate their research choices (e.g., is this the right statistical tool? Is my abstract logical?). Some even asked AI to critique or "humanize" their analysis for better defense preparation. Asking for critique, revision, or confirmation of decisions. With limited consultation time with their research instructor, AI tools became a 24/7 feedback mechanism, giving them confidence in their work and helping them revise according to academic standards.

4.1.7 Personalized learning needs
According to them, AI prompts are tailored based on their specific style, language preferences, and academic strengths. Some asked AI to write like them, match their tone, or refine their writing based on provided samples. As future educators, AI facilitated them to demonstrate metacognition and be mindful of their learning styles. These tools also served as personalized assistance, helping them write in ways that reflect their identity while still adhering to academic expectations. This interaction promotes learner-centered and differentiated learning strategies.

5. Discussion

The interplay between purpose, tool, and prompting behavior points to a maturing understanding among preservice science teachers of how AI can be harnessed as both a cognitive and metacognitive partner. While the tools addressed issues of access, clarity, and time efficiency, the prompting structures revealed strategic approaches to eliciting nuanced and helpful responses. These findings validate the claims of Mishra and Koehler (2023) on the need for contextualized AI literacy embedded in teacher education programs. The utilization of AI-driven smart prompts, which provide structured and context-aware guidance, can revolutionize how preservice science teachers engage in educational research, develop pedagogical strategies, and enhance scientific inquiry. AI scaffolds learning through adaptive feedback (Cope et al., 2021) and can improve student engagement in scientific investigations (Crompton et al., 2024).

Furthermore, AI-powered chatbots and research assistants enhanced student motivation, writing fluency, and conceptual organization (Ng et al.,2024). These advancements position AI as an essential tool in preservice science teacher education, equipping them with innovative methods for inquiry-based teaching and research. Despite these promising developments, concerns persist regarding over-reliance on AI, ethical biases, and the erosion of critical thinking skills. While Yang et al. (2024) demonstrated that AI-powered research assistance fosters deep

learning, other studies, such as those by Essien et al. (2024) and Nemorin et al. (2023), caution that excessive dependence on AI-generated feedback can lead to surface-level engagement with scientific concepts. Additionally, Pradana et al. (2023) identified gaps in AI's ability to accommodate diverse epistemologies, reinforcing dominant Western paradigms in scientific research. Furthermore, AI literacy among educators remains a significant barrier to adoption, as highlighted by Wang & Wang (2022), who found that AI anxiety significantly affects teachers' willingness to integrate AI into their pedagogical practices.

These findings underscore the critical need for structured AI literacy training within preservice teacher education programs. The extant literature reveals a gap in studies specifically examining how AI-driven smart prompts impact the research competencies of preservice science teachers. There is no study yet that has investigated how smart prompts influence research formulation, methodological rigor, and academic writing skills among future educators.

This study is relevant and necessary as there is a need to develop Artificial Intelligence (AI) literacy among people, especially students and teachers. AI Literacy is a new skill set of digital literacy referring to the technological attitudes, abilities, and competencies that enable people to use AI effectively and ethically in their daily life (Burgsteiner et al.,2016; Kandlhofer et al., 2016). With this new era of intelligence, there are fundamental skill sets that can help the person evaluate emerging AI technologies critically and communicate and collaborate with these technologies effectively (Long & Magerko, 2020; Ng et al., 2021).

In K-12 education, educators have started to employ different pedagogical strategies to foster students' AI literacy (Ng et al., 2021) to nurture the next generation to be digitally competent in AI skills and knowledge, better prepared for their future workplaces. Learners with these abilities could collaborate with their peers to learn new things by using computers and related technology in highly sophisticated ways (Kong et al., 2021) but in a very judicious and ethical manner (Robinson, 2020). As AI has emerged as a crucial technical competency in the twenty-first century, educators must integrate AI and literacy to provide students with the vital skills and attitudes necessary for thriving in our digital landscape shaped by AI-driven technology. AI literacy ought to be imparted across education levels (Steinbauer et al., 2021).

Students' limited understanding of how to critically assess AI outputs also exacerbates these concerns. Without proper training, many may interact with AI superficially, failing to evaluate its reliability, cite sources appropriately, or identify errors in generated content (Huang et al., 2022). As Wang and Wang (2022) noted, AI anxiety and lack of literacy can significantly affect the quality of AI usage in education. Moreover, some students may lack the discernment to identify when AI-generated suggestions conflict with academic conventions, leading to uncritical acceptance of flawed or inappropriate content. Another noted limitation is the tendency of AI tools to prioritize form over substance. While tools like Grammarly and Quillbot enhance sentence structure and tone, they may encourage formulaic writing that lacks depth or originality. This practice may

inadvertently suppress student voice and limit their engagement with the intellectual demands of academic discourse. Likewise, tools like Perplexity and ChatGPT may not consistently provide nuanced or culturally situated perspectives, raising concerns about the homogenization of research thinking. Thus, AI tools must be integrated alongside structured support, ethical guidelines, and ongoing training in AI literacy. Institutions must define boundaries, embed AI-related competencies in research training, and encourage students to reflect critically on their interaction with these tools.

This study affirms that AI tools, when used intentionally and strategically through smart prompts, can significantly enhance the research writing competence of students alongside a critical eye toward limitations, potential biases, and ethical responsibilities. The findings call for structured support in AI literacy and ethical use to prepare future educators who can leverage these technologies responsibly in both academic and instructional settings.

6. Conclusion

This study has shed light on the extent of utilization of various AI tools in education and academic research writing in the teacher training institution, particularly in their integration of AI tools and smart prompting strategies to enhance research writing. The findings affirm that AI, when leveraged intentionally and ethically, can serve as a robust scaffold in research conceptualization, design, analysis, and presentation. Students utilized AI not merely as a shortcut but as an extension of their learning environment that suited their contextual needs, academic challenges, and personal learning preferences.

However, the study also underscores the pressing need to address the inherent limitations, risks, and ethical considerations surrounding AI use in higher education to ensure that AI use remains a supportive tool rather than a substitute for authentic student engagement and academic rigor by employing mechanisms such as oral defense, journal log, or reflection paper, plagiarism check, among others. Future research could explore longitudinal studies to trace how AI-literate preservice teachers integrate AI into their professional practice post-graduation. Investigating the impact of AI-supported writing on deeper learning outcomes would enrich current understandings. Additionally, further studies could examine the role of smart prompting as a 21st-century literacy skill and its implications for curriculum design and assessment across disciplines.

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