

Research Article

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Integrating AI and Technology in Project-Based Learning for Academic Writing: Student Teachers' Experiences from Indonesia

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Abstract

Background/purpose. This study explores the experiences of Indonesian student teachers in utilizing artificial intelligence (AI) and digital technologies to complete academic journal article projects. It aims to understand how these tools shape their academic writing processes and professional learning as emerging scholars.

Materials/methods. Adopting a narrative inquiry approach, data were collected through interviews with five student teachers. The data were analyzed thematically to identify recurring patterns across several key dimensions: initial perceptions, project implementation, use of AI for sourcing and understanding materials, application of AI in writing and revision, challenges encountered, and strategies adopted to address them.

Results. The findings revealed that AI tools significantly enhanced the clarity, coherence, and academic quality of participants' manuscripts. Applications such as grammar checkers, paraphrasing tools, and citation generators facilitated clearer expression, enhanced literature discovery, and boosted students' confidence in producing publishable work. However, participants also encountered notable challenges, including overreliance on AI, concerns about academic integrity, and ethical ambiguities surrounding authorship and plagiarism.

Conclusion. These tensions highlight the paradox of AI-assisted writing: while it can strengthen academic performance, uncritical use may compromise scholarly voice and ethical standards. The study highlights the importance of establishing clear pedagogical frameworks that promote ethical literacy and critical engagement with AI among student teachers. By narrating these nuanced experiences, this research contributes to a deeper understanding of AI's evolving role in academic writing and offers actionable insights for educators, policymakers, and researchers seeking to integrate technology responsibly in higher education.

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1. Introduction

The convergence of artificial intelligence (AI), technology, and education has profoundly transformed the landscape of teaching and learning. AI-driven educational systems offer advanced capabilities, including individualized learning, adaptive feedback, enhanced instructional efficiency, and optimized student engagement (Adiguzel et al., 2023; ElEbyary & Shabara, 2024). In higher education, the growing emphasis on scholarly competence has accelerated the integration of AI into project-based learning (PjBL), creating opportunities to strengthen critical academic skills, particularly in academic writing (Mena-Guacas et al., 2023). Understanding how AI supports academic writing has therefore become an essential focus for educators and researchers aiming to prepare students for technology-mediated scholarship.

Grounded in constructivist theory, PjBL emphasizes student-centered inquiry and the application of knowledge in authentic contexts. Numerous studies have confirmed its effectiveness in fostering critical thinking, creativity, collaboration, and problem-solving skills (Newell, 2003; Sari & Prasetyo, 2021; Asfihana et al., 2022). By allowing learners to choose meaningful project themes, PjBL promotes engagement and fosters deeper intellectual participation (Greenier, 2020). However, its successful implementation depends greatly on adequate technological infrastructure and pedagogical support. Within this framework, AI acts as a strategic enabler, providing tools that help students manage complex academic writing tasks while supporting instructors in facilitating learning (Sweeney, 2024).

Recent pedagogical developments indicate that AI has emerged as a transformative force in language education and higher learning (Labadze et al., 2023; Kurniadi et al., 2025). AI facilitates personalized instruction, promotes learner autonomy, and enables immersive environments through the use of virtual and augmented reality (Shadiev et al., 2019). Furthermore, AI-based applications such as Grammarly, Turnitin, and Quillbot enhance writing accuracy, coherence, and academic integrity by offering real-time feedback and automated text improvement (Williyan et al., 2024; Prawiro et al., 2024). Despite these advantages, challenges persist, including limited access, uneven digital literacy, and the risks of overreliance on AI-generated outputs, as well as ethical concerns related to originality and authorship. These issues are particularly salient in contexts such as Indonesia, where digital access and pedagogical readiness continue to develop (Malik et al., 2023).

Although numerous studies have examined the pedagogical potential of AI in education, the majority have centered on its cognitive and technical contributions, such as improving writing quality, language accuracy, and task efficiency, rather than the lived experiences of learners engaging with AI during complex academic projects. Most of these studies have been conducted in technologically advanced or Western educational settings, where institutional support and digital infrastructure are well established (Sweeney, 2024). Consequently, there remains a limited empirical understanding of how student teachers in developing contexts, such as Indonesia, actually integrate, interpret, and negotiate the use of AI within project-based academic writing. While PjBL has been widely recognized for fostering critical thinking and collaboration, few investigations have addressed how AI can be meaningfully embedded within PjBL frameworks to enhance scholarly writing competence among pre-service English teachers, who are simultaneously learners and future educators. Furthermore, existing research on AI in academic writing predominantly adopted quantitative or experimental designs, focusing on outcome variables such as writing accuracy or task completion time (e.g., Alangari, 2025; Malik et al., 2023). These approaches offer limited insight into the narrative, reflective, and affective dimensions of learning with AI, specifically how student teachers experience uncertainty, develop self-efficacy, or navigate ethical dilemmas in authorship. In the Indonesian context, the integration of AI in teacher education is still emerging, often constrained by uneven digital literacy, lack of access to premium AI tools, and limited pedagogical guidance (Hamid et al.,

2025). This situation creates a pressing need to explore contextualized, experience-based accounts that reveal how student teachers navigate the opportunities and tensions of AI-assisted writing.

Therefore, the present study strived to fill these gaps by providing narrative evidence of how Indonesian student teachers employed AI and technology to complete journal article projects within a PjBL framework. By foregrounding their voices, emotions, and strategies, this study moved beyond performance metrics to uncover how AI participation shaped their academic writing identities, ethical awareness, and reflective practices as emerging scholars and future educators. Accordingly, this study explored Indonesian student teachers' experiences in using AI and technology to complete journal article projects within a PjBL framework. It aimed to understand how these tools shaped their academic writing processes, challenges, and adaptive strategies. Specifically, the study addressed the following research questions:

1. How do Indonesian student teachers integrate AI and digital technologies in completing their journal article projects?
2. What challenges and ethical considerations do they encounter in using AI tools for academic writing?
3. How do student teachers navigate and adapt their strategies to address these challenges within the PjBL framework?

By narrating these experiences, the study contributes to a deeper understanding of AI-assisted academic writing and provides insights for educators and policymakers seeking to integrate AI responsibly in higher education.

2. Literature Review

2.1. The Evolution of AI in Education and Its Pedagogical Implications

AI has significantly transformed educational frameworks by enhancing personalized learning and refining teaching methodologies. Since its conceptual origins in the 1950s, the influence of AI in education has expanded substantially, driven by advancements in deep learning (Chan & Zary, 2019). During the 1980s, Artificial Intelligence in Education (AIEd) emerged as a distinct discipline, focusing on the development of AI-powered classroom tools and the use of AI to assess and enhance learning processes (Williamson & Eynon, 2020). Adaptive learning systems and intelligent tutoring platforms exemplify this evolution by delivering individualized feedback, diagnosing learner needs, and improving educational outcomes (Shadiev et al., 2019; Labadze et al., 2023). The rise of generative AI (GenAI) has further expanded these capabilities by introducing automated grading, interactive learning environments, and academic writing support (Shishavan, 2024). Recent innovations in English as a Foreign Language (EFL) instruction demonstrate significant promise, where AI facilitates personalized lessons, optimizes assessments, and fosters higher-order cognitive skills, such as critical thinking and collaboration (Bin-Hady et al., 2023). However, to fully realize AI's pedagogical potential, educators must address ongoing challenges, including technological inequities, ethical considerations, and insufficient teacher preparedness (Godwin-Jones, 2022). As universities increasingly integrate AI, including GenAI, into their curricula, the emphasis on ethical, inclusive, and equitable practices has become crucial to ensuring that technological advancements align with educational goals and learning objectives (Shishavan, 2024).

2.2. PjBL as a Catalyst for Skill Development

PjBL is an effective pedagogical approach that bridges theoretical knowledge and practical application, equipping students with essential competencies for the 21st-century workforce. Crespi et al. (2022) reported enhanced communication and collaboration skills among university students in Madrid. Similarly, Belwal et al. (2020) found that Omani students participating in consultancy

projects developed stronger communication abilities, greater self-confidence, and improved time management. Beyond interpersonal skills, PjBL also supports the development of higher-order cognitive and creative competencies. Saimon et al. (2022) emphasized PjBL's role in cultivating the "4Cs" (critical thinking, communication, collaboration, and creativity) within Tanzanian college settings. Mou (2020) demonstrated that 3D design courses employing PjBL promoted self-regulated learning, problem-solving, and reflective practices, ultimately enhancing student motivation. Pou et al. (2022) highlighted PjBL's contribution to advancing computational thinking and educational robotics in STEM education. Furthermore, Li and Zhu (2023) observed that blended PjBL environments improved transferable skills such as teamwork, project management, and presentation capabilities, particularly when paired with academic motivation and well-designed curricula. Although challenges such as large class sizes and limited technological infrastructure persist, Saimon et al. (2022) suggested that these barriers can be mitigated through strategic curriculum planning and sustained collaboration among educators. Collectively, the evidence underscores PjBL's effectiveness in fostering critical, transferable, and industry-relevant skills essential for navigating today's complex global landscape.

2.3. AI Integration in PjBL for Academic Writing: Unaddressed Challenges and Opportunities

The integration of AI into PjBL for academic writing marks a significant advancement in educational methodology, presenting both transformative opportunities and multifaceted challenges. AI-powered tools such as ChatGPT, Grammarly, and Quillbot optimize key writing processes, including drafting, editing, and citation management, thereby enhancing the quality, engagement, and efficiency of student writing (Alangari, 2025; Willian et al., 2024). These technologies provide personalized scaffolding that strengthens argumentation, coherence, and revision skills, particularly for second-language (L2) learners (Kim et al., 2022; Link et al., 2020; Rad et al., 2023). Furthermore, AI supports academic publishing by generating multilingual content and reducing linguistic barriers for non-native English speakers (Liebrenz et al., 2023). It also fosters critical thinking and data literacy as students evaluate AI-generated content, thereby deepening their engagement in the writing process (Loftus & Madden, 2020; Al-Bawaleez & Turkey, 2025). Participatory writing analytics further promote iterative writing development (Zhai & Ma, 2021). Despite these benefits, significant challenges remain. Concerns related to academic integrity, the limited nuance of automated writing evaluation (AWE) systems, risks of misinformation, and economic disparities in access to AI technologies complicate its pedagogical implementation (Yeo, 2023; Shaw et al., 2023; Liebrenz et al., 2023). Addressing these challenges requires ethical, equitable, and pedagogically sound strategies to fully harness the potential of AI in academic writing instruction.

2.4. Bridging the Gap: Contextualizing AI in PjBL for Student Teachers

Integrating AI into PjBL for pre-service teachers requires a context-sensitive approach to enhance pedagogical skills, technological fluency, and classroom readiness. Empirical research underscores the effectiveness of collaborative design teams in developing technological, pedagogical, and content knowledge (TPACK), suggesting that AI, through real-time feedback and adaptive learning capabilities, can further advance these competencies (Tan et al., 2020). The automation of structured feedback, exemplified by contextualized evaluation checklists, offers scalable solutions for improving the assessment of instructional materials in teacher education (Shieh et al., 2023). Community partnerships enriched by AI-simulated diverse classroom scenarios facilitate the practical application of critical pedagogies in authentic teaching contexts (Lee et al., 2023). Virtual development programs emphasizing translanguaging practices further highlight AI's role in promoting linguistic inclusivity and supporting emergent bilingual learners (King et al., 2024). Moreover, AI enhances apprenticeship

experiences by providing data-driven insights and fostering collaborative learning within PjBL settings (Para-González et al., 2023), while dialogic and multimodal AI tools improve interaction and student engagement in virtual classrooms (VanDerHeide & Dunn, 2022). AI-supported simulations and virtual practicums help bridge the persistent theory–practice divide (Mandyata et al., 2023), and AI-enhanced scaffolding strengthens discussion facilitation skills (Chung & Heny, 2022). While concerns regarding academic integrity persist, the integration of AI in teacher education presents considerable opportunities to enrich writing instruction, stimulate creativity, and prepare pre-service teachers with adaptable, future-ready teaching competencies.

3. Methodology

3.1. Research Design and Procedures

This study focused on the integration of AI and technology by student teachers in Indonesia to complete a journal article project within a PjBL framework. A narrative inquiry approach was employed to analyze participants' experiences across several key dimensions: initial perceptions, project implementation, utilization of AI for sourcing and understanding materials, application of AI in writing and revision, challenges encountered, and strategies adopted to address those challenges. The study provides empirically grounded insights into the effective incorporation of AI in project-based academic writing, contributing to theory and practice in teacher education. Narrative inquiry effectively understands human experiences through storytelling, providing deep insights into lived phenomena (Kim, 2016). In educational contexts, narrative research is closely associated with teacher reflection and requires the systematic organization of collected narratives, including personal accounts from student teachers, to enhance interpretive depth (Creswell, 2015). Interviews are a valuable data collection method in narrative studies, allowing researchers to explore participants' lived experiences in depth (Hollingsworth & Dybdahl, 2007; Rogers, 2007). All interviews were recorded and transcribed verbatim to ensure accuracy during data analysis. Informed consent was obtained from all participants prior to data collection, adhering to ethical research standards.

3.2. Research Participants

A purposive sampling technique, primarily associated with qualitative research, enables researchers to intentionally select participants based on their relevance to, or representativeness of, the study's objectives (Cohen et al., 2007). In this study, five student teachers from the English Education Department were purposefully selected according to three key criteria. *First*, they had prior experience with PjBL and had utilized AI and technology to complete academic projects. *Second*, they demonstrated outstanding academic achievement, having earned an "A" grade in relevant coursework. *Third*, they maintained a cumulative GPA of 3.5 or higher, indicating strong academic proficiency.

Table 1. Participant Information

No.	Student	Gender	Research Score	GPA (out of 4)
1.	S1	Female	A	3.87
2.	S2	Female	A	3.94
3.	S3	Female	A	3.80
4.	S4	Female	A	3.84
5.	S5	Male	A	3.74

3.3. Data Collection

To generate meaningful insights into student teachers' experiences of using AI and technology within PjBL contexts, data were collected through semi-structured interviews designed around 10 main indicators and 10 corresponding open-ended questions. These indicators were developed to explore multiple dimensions of participants' experiences throughout the PjBL process and their engagement with AI tools at different stages. The indicators included: 1) Lived experiences of engaging in PjBL (e.g., types of projects, learning contexts, emotional and cognitive engagement); 2) Chronological process of engaging with PjBL (e.g., initial reactions, reflection, project stages); 3) Emotional and cognitive responses to PjBL introduction (e.g., feelings of surprise, anxiety, excitement, or motivation); 4) Integration of AI/tools during the project (e.g., types and functions of AI tools or platforms used); 5) Role of AI in information discovery (e.g., AI-assisted search for references or academic sources); 6) AI as a cognitive aid for comprehension (e.g., summarizing, translating, or simplifying academic texts); 7) Role of AI in drafting content (e.g., use of AI for outlines, abstracts, or phrasing support); 8) AI support in the revision stage (e.g., grammar checking, coherence analysis, and referencing aids); 9) Barriers and ethical dilemmas (e.g., dependence on AI, misinformation, ethical concerns, and institutional policy constraints); and 10) Coping and adaptive strategies (e.g., critical AI literacy, seeking guidance, ethical self-regulation, and integrating AI with peer feedback).

The PjBL-based course took place from March to August, and interviews were conducted in September, immediately following the course's completion. This scheduling allowed participants to reflect holistically on their learning experiences, the pedagogical processes they underwent, and their use of AI tools throughout the project stages. Each interview lasted approximately 60 minutes and was conducted in an informal and conversational manner to create a comfortable atmosphere that encouraged open sharing. The sessions began with broad, open-ended questions (e.g., *"Would you share your experience in learning research in education by using project-based learning?"*) and progressively moved toward more specific inquiries about the integration, challenges, benefits, and ethical aspects of AI-supported learning. All interviews were audio-recorded with participants' consent and later transcribed verbatim to ensure accuracy and completeness of the data.

3.4. Data Analysis

The interview transcripts were analyzed using Braun and Clarke's (2006) six-phase thematic analysis framework. This approach provided a systematic and flexible process for identifying and interpreting patterns of meaning within the qualitative data. The analysis involved six iterative stages: 1) Familiarization with the data, through repeated reading of the transcripts to gain an in-depth understanding of participants' narratives; 2) Generating initial codes, by systematically highlighting meaningful segments related to the ten indicators; 3) Searching for themes, through grouping codes into potential thematic categories reflecting shared experiences or viewpoints; 4) Reviewing themes, by comparing emerging themes against the dataset to ensure consistency and coherence; 5) Defining and naming themes, to refine the essence of each theme and articulate its relevance to AI-supported PjBL; and 6) Producing the final report, which involved synthesizing the findings into coherent thematic insights that captured the pedagogical implications of AI and technology integration.

This rigorous analytical process enabled the identification of recurring patterns and critical reflections concerning how student teachers engaged with AI tools, navigated ethical challenges, and developed adaptive strategies to enhance their research-based learning. Ultimately, the analysis provided a deeper understanding of how AI-assisted PjBL influenced student teachers' learning outcomes, academic writing development, and professional growth as future educators.

4. Results

The findings of this study are presented through a thematic analysis of narrative accounts gathered from five student teachers (ST1–ST5) who participated in a PjBL experience culminating in the production of a journal article.

4.1. Theme 1: Student Teachers' Initial Reactions to the Journal Article Project

4.1.1. Initial Anxiety and Self-Doubt

The participants' narratives revealed substantial apprehension and self-doubt at the project's outset. This anxiety stemmed from their limited familiarity with academic research and the perceived difficulty of producing a scholarly article within a constrained timeframe. One participant expressed:

"I'm scared, Sir. Actually, I'm worried too. Will I be able to write a journal? [...] it's only a short time, only two months. I don't think the time is long, right? Moreover, if you're writing a journal, you have to do research, go to the field [...] I'm afraid I can't do it in that time." (ST1)

This statement exemplifies the emotional strain students experienced while managing expectations and deadlines during the initial phase of the project.

4.1.2. Confronting the Challenge

Despite their initial fears, participants gradually began to perceive the experience as both a challenge and an opportunity for intellectual growth. This stage was characterized by an acknowledgment of the task's complexity and the motivation it generated.

"First of all, it's like, wow, that's challenging. Previously, I've never written a research paper [...] Moreover, writing a journal article requires a lot of words; we also have to collect data. It was challenging at first, but it's also interesting." (ST2)

This narrative highlights a shift from apprehension to engagement, emphasizing the dual nature of the task as both daunting and stimulating.

4.1.3. Emergence of Self-Efficacy through Collaborative Learning

As the project progressed, participants began to develop a sense of self-efficacy through collaborative learning. One student shared:

"Fortunately, the Research in Education lecture was very interesting, because I had never made a journal article at all before." (ST5)

A prominent theme that emerged was the significance of collaboration and structured guidance in enhancing students' confidence. The course's supportive design and team-based approach played a crucial role in reducing anxiety and fostering students' ability to complete the task successfully.

4.2. Theme 2: Student Teachers' Journey Through Project Execution

4.2.1. Guided Preparation and Topic Selection

The lecturer facilitated a well-organized orientation process during the project's initial phase. Participants were introduced to fundamental concepts related to academic writing and research methodology. ST1 described the structured process:

First, the lecturer explained materials on how to write articles, and what methods can be used for writing articles. Then, we were divided into several groups to write a journal article. There, we were free to choose what problem we wanted to raise. [...] We started writing parts of the article, [...] identifying the problem and continued by analyzing the data." (ST1)

This structured sequence encouraged both autonomy and collaboration, laying a strong foundation for the research project.

4.2.2. Iterative Development through Weekly Milestones

A consistent theme across participants' narratives was the implementation of a weekly milestone model to guide project development. This approach allowed students to gradually construct their journal articles section by section.

"So, there are milestones we achieve every week. For example, this week, we did the introduction section. Next week, we will do the discussion section, and so on." (ST2)

This regular cadence of deliverables helped maintain momentum and reduced feelings of being overwhelmed. The iterative structure also encouraged sustained engagement with each component of the research process, from title formulation to data analysis.

4.2.3. Integration of Theory and Practice through Continuous Support

The narratives strongly underscore the lecturer's multifaceted role as evaluator, facilitator, and mentor. The continuous integration of theoretical concepts with hands-on application fostered deeper understanding and reflective learning. As ST2 noted:

"Because in addition to being given material in each meeting, we were also immediately faced with practice [...] the knowledge gained, the new material, was still fresh, and we immediately applied it to our project." (ST2)

This immediate application reinforced students' comprehension while simultaneously strengthening their research competencies.

4.2.4. Formative Feedback and Mentorship as a Catalyst for Progress

Students consistently emphasized the significance of weekly consultations and the lecturer's ongoing guidance. These sessions served a formative function, allowing students to revise their work, clarify concepts, and sustain motivation throughout the process. As ST1 shared:

"We always discuss and communicate with the lecturer [...] We are told what is missing and what needs to be improved." (ST1)

ST4 further elaborated:

"We also met with the lecturer in her office. We were guided there, and thank God the lecturer was kind and responsive." (ST4)

These mentorship interactions not only supported the project's technical aspects but also contributed to students' emotional well-being, serving as catalysts for continuous progress and academic growth.

4.3. Theme 3: The Use of AI and Technology in Sourcing Literature for Journal Article Writing

4.3.1. Diverse Tools and Platforms for Literature Retrieval

Students reported using a range of both traditional and AI-powered platforms to locate scholarly sources. A notable shift toward tools such as Perplexity, SciSpace, Scite, Elicit, Blackbox AI, ResearchRabbit, and Publish or Perish reflects students' evolving strategies for identifying relevant literature. As ST1 explained:

"To find articles that I need as references, I usually use Google Scholar and Perplexity." (ST1)

This statement illustrates a hybrid model of information seeking, in which students combined the reliability of established databases with the efficiency of AI in filtering and synthesizing content. Their adoption of AI-supported platforms also reflects an increasing awareness of emerging technologies in academic research.

4.3.2. AI as a Tool for Efficiency, Accessibility, and Comprehension

Students did not adopt AI tools merely as a trend; instead, they selected them based on functionality and accessibility. For instance, ST3 shared:

"I use Scite, Perplexity, and SciSpace. But most often I use SciSpace because I think SciSpace has a large selection of journals and is easy to use." (ST3)

This preference for user-friendly AI tools indicates a pragmatic approach to selecting platforms that reduce cognitive load and enhance research productivity. Students' choices also reflect a need for tools that facilitate comprehension of complex journal articles through features such as simplified abstracts, keyword extraction, and annotated summaries, which are functionalities increasingly available in AI-supported research platforms.

4.3.3. Building Global-Local Research Perspectives

The integration of both national (e.g., SINTA) and international sources (e.g., DOAJ, Scite) illustrates students' growing ability to situate their research within both local and global scholarly contexts. ST5 and ST4 reflected:

"I usually search in SINTA. Besides that, I also use AI such as Blackbox AI and ResearchRabbit to find articles as my reference sources." (ST5)

"I usually search DOAJ.org and Publish or Perish to find articles. There, we can search for both national and international journals." (ST4)

These narratives reveal the emergence of critical research literacy, as students became increasingly aware of the importance of grounding their topics in both culturally relevant and globally recognized discourses. Their strategic use of AI-supported databases for cross-contextual research marks a significant step toward developing nuanced and comparative academic perspectives.

4.4. Theme 4: The Use of AI and Technology to Understand Sources

4.4.1. Strategic Use of Summarizing Tools for Quick Understanding

Students frequently utilized summarizing tools such as ChatPDF and GetDigest to quickly grasp the main ideas of lengthy journal articles, particularly when working under time constraints. As ST2 explained:

"If the time is longer, I usually read it myself with the help of Google Translate. But if the time is already tight, I use ChatPDF." (ST2)

This narrative illustrates a flexible learning strategy that balances manual reading with AI assistance, depending on the urgency and workload. In this context, AI functioned as a time-saving aid, allowing students to engage meaningfully with the material despite limited time. By blending independent reading with technological support, students demonstrated self-regulated learning as they navigated complex academic texts.

4.4.2. AI as Cognitive Support for Comprehension and Clarification

Tools such as Claude AI, DeepL, and Humata AI were employed not only for retrieving information but also for enhancing comprehension, particularly when students encountered difficult concepts or technical language. ST3 shared:

"I use Humata AI to read PDFs quickly. There is also Claude AI. It can answer many questions and simplify things. For explanation, we still don't understand, but Claude can explain them very well." (ST3)

This suggests that students did not passively consume AI outputs, but rather actively engaged with these tools to resolve confusion, translate content, and deepen their understanding of the material. Such practices reflect increasing metacognitive awareness: students recognized when they struggled and took deliberate steps to clarify their understanding using appropriate digital sources.

4.4.3. Reducing Cognitive Load through AI Assistance

For some students, AI tools also served to alleviate cognitive strain, mental fatigue, and stress, particularly when dealing with dense or demanding academic texts. As ST5 noted:

"If I have a headache, I usually just use ChatPDF." (ST5)

Although simple, this statement highlights the emotional and cognitive load often associated with academic reading and how technology can function as a coping strategy. Rather than disengaging entirely, students found ways to remain engaged in learning, demonstrating resilience and resourcefulness in managing academic demands.

4.5. Theme 5: The Use of AI and Technology to Assist in Writing Journal Articles

4.5.1. AI as a Brainstorming and Idea-Generating Tool

Students frequently employed AI tools, such as ChatGPT and Perplexity, to overcome writer's block and generate ideas, particularly in sections like the literature review, where synthesizing multiple sources is essential. ST2 shared:

"To help me write, I use ChatGPT, especially when I'm confused about what to write. In addition, I also use Perplexity for help." (ST2)

This excerpt suggests that AI functioned not merely as a writing tool but as a cognitive partner, guiding students from uncertainty to clarity. The integration of these platforms reflects students' adaptive strategies for managing academic challenges. Rather than replacing original thinking, AI was used to scaffold and organize initial thoughts into more structured academic writing.

4.5.2. Multi-Tool Approach to Support Drafting and Structure

Some students combined multiple AI tools, such as Consensus, Claude, and Perplexity, to support various stages of the writing process, demonstrating a nuanced understanding of each platform's strengths. As ST3 explained:

"I use Consensus and Claude AI in writing articles. These two AIs really help me finish my writing." (ST3)

This illustrates that students did not rely on a single solution but critically selected tools based on specific needs, such as summarizing evidence, expanding explanations, or refining academic tone. This ability to curate and combine tools indicates growing digital literacy and an emerging sense of research autonomy among pre-service teachers.

4.5.3. Practical and Ethical Considerations in Tool Selection

Cost and accessibility also influenced students' choices of AI tools. Free platforms such as ChatGPT were commonly used, particularly during the early stages of writing when basic guidance was sufficient. As ST5 noted:

"I just use ChatGPT, sir to write, because ChatGPT is free, so it's enough to give ideas, for example, what to write in the literature review section." (ST5)

This reflects students' practical awareness of resource limitations coupled with strategic decision-making in technology use. They maximized the use of freely available tools while maintaining a focus on academic standards. Although AI assisted in generating initial content, students remained responsible for refining and contextualizing the output to meet scholarly expectations and uphold academic integrity.

4.6. Theme 6: The Use of AI and Technology to Revise, Develop, and Conclude Journal Articles

4.6.1. AI-Based Tools for Editing, Paraphrasing, and Summarizing

Students relied on AI tools such as Quillbot and ChatGPT to assist in revising and paraphrasing their writing. These tools were instrumental in clarifying arguments and summarizing sections effectively. As ST2 explained:

"Quillbot for me is very helpful for improving the sentences I have made, because there are paraphrasing options. I also use ChatGPT to make summaries." (ST2)

This highlights the role of AI as a revision assistant, such as enhancing sentence structure, simplifying content, and supporting the conclusion-writing process. Rather than starting from scratch, students engaged in iterative improvement guided by AI-generated feedback.

4.6.2. Step-By-Step Revision Using Multiple AI-Based Platforms

Some students described a structured, multi-stage revision process that involved several AI tools sequentially, beginning with paraphrasing, followed by grammar correction, and concluding with plagiarism detection. ST4 elaborated:

"Firstly, I use Quillbot to paraphrase the sentence to make it easier to understand. Only when I have gone back and forth using Quillbot and Grammarly do I check the plagiarism using Turnitin." (ST4)

This step-by-step approach demonstrates students' growing familiarity with academic writing conventions and their commitment to ethical writing. AI was not simply used to bypass effort but integrated as part of a multi-phase editing strategy that included critical thinking and self-correction. Their workflow demonstrates metacognitive awareness, as students planned, monitored, and evaluated their revisions carefully.

4.6.3. Grammar Accuracy and Academic Integrity

Grammar tools such as Grammarly were widely used to correct linguistic errors and improve the overall readability of students' texts. Combined with Turnitin, these tools supported academic integrity by ensuring low similarity scores. As ST3 shared:

"I use Grammarly to check whether there are mistakes or not... Then I use Quillbot, which is premium for paraphrasing. After paraphrasing, I check Turnitin." (ST3)

This layered application of AI reflects students' deepening understanding of academic writing standards. Their focus extended beyond fluency to originality and scholarly responsibility. By integrating grammar correction and plagiarism detection into their workflow, students became more confident in the quality and credibility of their writing.

4.7. Theme 7: The Student Teachers' Challenges in Using AI and Technology in Writing Journal Articles

4.7.1. Difficulty in Crafting Effective Prompts and Search Keywords

Students frequently struggled to construct clear and specific prompts, particularly when using tools such as ChatGPT or when searching for articles in academic databases and search engines. As ST2 described:

"It seems like the difficulty is making the right prompt... because this is also our first time making journal articles so I have a lot of pressure..." (ST2)

This response highlights the learning curve associated with mastering prompt engineering, which demands precision, critical thinking, and contextual understanding. Students were still in the exploratory phase of effectively utilizing AI, often relying on trial and error to achieve relevant results.

4.7.2. Limited Access to Updated and Relevant Sources

Another significant challenge involved locating up-to-date and relevant sources, particularly for research instruments or specialized topics. Students often needed to revise their search queries multiple times because they encountered outdated or irrelevant materials. As ST3 explained:

"...especially references for instruments. I had to change many times... Or maybe the instrument is too old... so we really spend the longest time alone..." (ST3)

This excerpt highlights the challenge of sifting through extensive academic databases to identify relevant materials. It also highlights a discrepancy between the existing literature and students' specific research requirements. Even with AI assistance, human judgment, persistence, and repeated effort remain crucial components of the research process.

4.7.3. Constraints in Free Versions of AI-Based Tools

Students encountered limitations when using free versions of AI platforms, which often restricted access to advanced features or generated incomplete results. As ST4 shared:

"...because I'm using a free AI, so the difficulty is in the limitations of using the AI..." (ST4)

This reflects a form of digital divide in which financial constraints hinder the full utilization of technological resources. These limitations underscore the need for institutional support, such as providing access to premium tools or training programs that maximize free alternatives. Overreliance on restricted platforms may affect the depth, quality, and efficiency of students' research outputs.

4.7.4 Repetition and Trial in Finding Relevant Studies

Several students described the difficulty of identifying studies that directly aligned with their research focus, which required multiple search attempts and critical evaluation. As ST5 remarked:

"...there are some specific references that I need... but once read it turns out that there is no information needed. So I have to keep repeating myself..." (ST5)

This reinforces the reality that AI tools do not automatically ensure relevance, particularly for nuanced academic inquiries. It also emphasizes the importance of research literacy, including the ability to assess, select, and synthesize sources effectively. In navigating these challenges, students gradually developed more critical and strategic approaches to scholarly information retrieval.

4.8. Theme 8: Student Teachers' Strategies to Overcome Challenges in Using AI and Technology

4.8.1. Experimenting with Prompts and Keywords

One of the most common strategies students employed was trial and error, continually refining keywords and prompts to achieve more relevant results. As ST1 shared:

"I just keep trying to use new keywords or prompts, until I find them." (ST1)

This demonstrates students' persistence and growing digital literacy. It also reflects a hands-on, experiential learning process through which students built confidence and competence in navigating AI tools and academic databases.

4.8.2. Upgrading to Premium Tools for Better Features

Some students chose to invest in premium versions of AI platforms to access advanced features and avoid usage limitations. As ST3 explained:

"I use some premium AIs such as Quillbot and SciSpace... because if you use premium ones, there are more options, and there is no limit to the number of words." (ST3)

This reflects students' increasing awareness of the value of these tools in enhancing academic productivity and output quality. Their willingness to invest demonstrates a commitment to improving both the efficiency and the scholarly rigor of their writing.

4.8.3. Creative Use of Multiple Accounts to Extend Access

To address the limitations of free AI tools, some students used multiple email accounts or borrowed friends' accounts to maintain access to essential AI services. As ST4 explained:

"Use several emails, use friends'. Then, if it's already limited, make a new email to use the AI we need." (ST4)

This demonstrates adaptability and digital problem-solving, reflecting students' creative approaches to overcoming technological barriers. It also highlights their resourcefulness in navigating access restrictions while drawing attention to the broader issue of inequitable access to digital tools within educational contexts.

4.8.4. Taking Breaks to Regain Focus and Mental Clarity

Some students recognized the importance of taking breaks to rest and recharge, allowing them to return to their academic tasks with renewed concentration. As ST5 shared:

"I rest first. Because if I'm tired, it's hard to think. So take a break first, then if you suddenly have an idea, just open the laptop again..." (ST5)

This narrative reflects emotional intelligence and self-regulation in managing academic workloads. It also suggests that productivity is not solely dependent on technology but can be enhanced through mindful practices that prioritize mental well-being and sustainable learning habits.

5. Discussion

The findings revealed that AI tools substantially enhanced the clarity, coherence, and structural quality of participants' academic writing. Grammar checkers, paraphrasing platforms, summarization tools, and AI-powered literature databases enabled student teachers to produce more polished and organized manuscripts. However, these benefits coexisted with critical challenges, including difficulties in rapid formulation, limited access to premium tools, and ethical dilemmas regarding originality and authorship. Moreover, instructor guidance, collaboration, and iterative feedback

emerged as significant mediating factors that strengthened students' self-efficacy and critical engagement with AI throughout the PjBL process. The improvement in writing quality and confidence aligns with prior studies emphasizing AI's capacity to scaffold complex cognitive and linguistic processes (Malik et al., 2023; Ozfidan et al., 2024; Sweeney, 2024). Similar to the findings by Kim et al. (2022) and Link et al. (2020), participants in this study utilized AI as a metacognitive partner that supported brainstorming, drafting, and revision, rather than as a replacement for human authorship. The iterative integration of AI, combined with human feedback, mirrors the findings of Ducasse et al. (2023) and Viosin et al. (2023), who found that structured feedback cycles and technology-supported reflection foster sustained writing development and reduce anxiety in higher education contexts.

The role of collaboration and mentoring in mediating AI use further supports the social-constructivist framework proposed by Li et al. (2024), who noted that dialogic and supportive environments enable more ethical and effective technology adoption in teacher education. Similarly, the use of AI-based literature search tools (e.g., SciSpace, Perplexity) in this study aligns with Heidt (2023) and Bolanos et al. (2024), demonstrating how generative and retrieval AIs expand access to high-quality academic resources, an especially significant advantage for scholars in developing educational systems, such as Indonesia's. Nonetheless, the study also revealed persistent tensions around ethics and dependence, which resonate with critiques by Ivanov (2023), Yeo (2023), and Liebrez et al. (2023) about the risks of academic dishonesty, fabricated references, and the erosion of an authentic scholarly voice. The participants' struggles in prompt engineering and information filtering illustrate what Robertson et al. (2024) describe as the emerging literacy gap between AI capability and human critical judgment. However, student teachers' adaptive strategies, such as iterative prompt refinement, collaborative problem-solving, and selective upgrading to premium tools, reflect the development of digital resilience, echoing findings by Almajdoub et al. (2025) and Hidayat-ur-Rehman (2024).

The study extends current understandings of AI in education by illustrating how technological scaffolding and human mentorship jointly shape learners' academic identity formation. Unlike prior research, which has primarily focused on cognitive or quantitative writing outcomes (e.g., Alangari, 2025), this study explored the affective and ethical dimensions of AI-assisted writing through a narrative inquiry approach. It revealed that AI does not merely function as a mechanical aid but as a cognitive collaborator whose value depends on pedagogical framing and learner agency. This perspective contributes to a more nuanced model of AI integration in teacher education, one that situates technology within social, ethical, and reflective dimensions of learning. Moreover, this study foregrounds AI ethical literacy as a core pedagogical outcome. Consistent with Zlotnikova et al. (2025), this underscores the need to embed responsible AI use in curricula through critical dialogue about authorship, originality, and intellectual ownership. The participants' reflections reveal that ethical awareness evolves through experience and mentorship, not merely through policy enforcement.

Practically, the findings highlight the importance of structured, guided frameworks for AI integration in academic writing courses. Lecturers must provide not only technical training but also moral scaffolding, ensuring that AI complements rather than replaces human cognition. This echoes Ou et al. (2024), who advocate for post-humanist pedagogies that balance machine assistance with human interpretation and creativity. Institutional support is also vital: universities should ensure equitable access to AI tools, provide workshops on prompt engineering and digital discernment, and create spaces for collaborative reflection on ethical dilemmas. The participants' resilience, demonstrated through creative problem-solving (e.g., multiple accounts, peer sharing, breaks for self-regulation), also reaffirms the role of emotional intelligence in technology-mediated learning. This finding contributes to discussions by Voisin et al. (2023) on how supportive learning

environments and self-regulatory strategies foster motivation and sustained engagement in higher education.

This research makes a unique contribution by offering contextualized narrative insights from a Global South setting where access to technology and pedagogical infrastructure remains uneven. Few previous studies have examined AI-assisted writing through the lens of PjBL in teacher education within developing contexts. By capturing lived experiences and adaptive behaviors, this study provides a grounded understanding of how future educators internalize AI as both a pedagogical partner and an ethical challenge. It bridges the gap between global discussions on AI literacy and localized educational realities, offering evidence that ethical, guided, and collaborative integration of AI can transform writing pedagogy and enhance students' readiness for digital scholarship.

6. Conclusion

This study illuminated Indonesian student teachers' complex and varied trajectories as they engaged with AI and digital technologies in academic journal writing. By capturing situated experiences through a narrative inquiry approach, this research enhanced understanding of the dynamic interplay between emerging AI tools and academic writing practices within teacher education. The findings indicate that judicious AI use significantly influenced participants' academic writing quality, accuracy, and efficiency. AI-driven platforms facilitated the articulation of well-structured arguments, enhanced linguistic precision, and supported advanced paraphrasing and text refinement. Moreover, participants effectively leveraged AI tools to broaden their literature searches, generate relevant keywords, and stimulate creative thinking, thereby strengthening the structural coherence of their manuscripts. However, these advantages were accompanied by notable challenges that underscore the complexities inherent in AI-assisted academic work. Issues related to academic integrity, the erosion of individual expression, and the risk of overreliance on AI-generated content emerged as significant concerns. Participants emphasized the importance of continuous critical scrutiny when evaluating the accuracy and reliability of AI outputs, given the systems' propensity for errors and fabricated citations. The ethical dilemmas surrounding plagiarism and the responsible use of AI underscore the need for careful discernment and thoughtful engagement. These dynamics reveal a fundamental tension; while AI technologies offer widespread academic support and cognitive augmentation, their uncritical use may compromise essential scholarly competencies and ethical standards.

Despite its contributions, this study has several limitations that should be acknowledged. *First*, the research involved only five participants from a single teacher education program, limiting the generalizability of the findings to broader contexts. *Second*, the data relied on self-reported narratives, which, while rich in depth, may not capture all underlying cognitive or behavioral aspects of AI use in academic writing. *Third*, the rapid evolution of AI technologies means that the tools and user experiences discussed here may soon become outdated. Future research could expand the participant pool, employ mixed-method or longitudinal approaches, and explore diverse institutional or cultural contexts to generate more comprehensive insights into the pedagogical integration of AI in higher education. Nonetheless, the findings yield several key implications for teacher education. Foremost, there is a pressing need for structured, pedagogically sound frameworks to guide the incorporation of AI in academic writing instruction. Educators must establish clear guidelines that promote critical engagement, proper attribution, and responsible application, thereby safeguarding the integrity of academic authorship. Embedding comprehensive ethical education within teacher training programs is essential to equip future educators with the knowledge and moral discernment required to navigate the evolving landscape of AI-assisted research.

7. Suggestion

This study highlights the need for Indonesian lecturers to adopt structured pedagogical frameworks that deliberately integrate AI literacy into PjBL models for academic writing. Guided instruction, formative feedback, and collaborative learning were found to help student teachers progress from initial anxiety to increased confidence in their writing abilities. Consequently, curricula should include systematic training in both the technical and ethical dimensions of AI-assisted research. Such training should encompass skills in prompt engineering, advanced literature search strategies, and the critical evaluation of AI-generated outputs, while emphasizing the importance of maintaining an authentic scholarly voice. To ensure equitable participation in AI-supported research, institutions should provide students with access to advanced AI tools through subscriptions or institutional licenses. This would help mitigate disparities in access and ensure that the quality and ethical standards of student work are upheld.

Future research should explore how AI-integrated writing instruction influences the development of scholarly identity and independent research skills over time. Comparative studies across cultural, institutional, and disciplinary contexts could deepen the understanding of how AI integration shapes both teaching practices and academic expectations. Further investigation is also needed to determine how educators can balance cognitive assistance with the risk of cognitive dependency, promoting critical thinking while leveraging the efficiency and speed of AI. Employing mixed-method or longitudinal narrative approaches would provide valuable insights into how long-term use of AI tools affects research independence, ethical reasoning, and publication success. Collectively, such studies would advance theoretical understanding and inform evidence-based practices for integrating emerging technologies into higher education worldwide.

Declarations

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Ethical Approval. Prior to the commencement of the project, ethical approval was obtained from the relevant authorities at Universitas Wiralodra, the location of data collection. Informed consent was obtained from five student teachers after they were thoroughly briefed on the study's objectives, methodologies, and confidentiality protocols. All study activities adhered to established ethical norms to safeguard participants' rights, privacy, and welfare throughout the process.

Data Availability Statement. The data supporting the results reported in this study are available upon request from the corresponding author.

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