



ENHANCING ACADEMIC WRITING IN HIGHER EDUCATION: THE IMPACT OF CHATGPT AND QUILLBOT IN AI-DRIVEN PROJECT-BASED LEARNING

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ABSTRACT

Aim/Purpose This study aims to investigate the role of ChatGPT and Quillbot in improving students' scientific writing abilities within a project-based learning (PjBL) framework.

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Background	A preliminary study found that many students struggled with clarity, analytical precision, and organization in academic writing. These challenges reflect broader literacy issues in Indonesia, which are shaped by limited exposure to structured writing, an emphasis on rote learning, and the predominance of non-English discourse. AI tools, such as ChatGPT and Quillbot, can support improvements in coherence and structure; however, their use should be balanced to avoid overreliance and to foster independent thinking and writing skills.
Methodology	A mixed-methods approach with an explanatory design model was employed. Participants were undergraduate students from the guidance and counseling study program, all enrolled in the same scientific writing course, drawn from three private universities in West Java, Indonesia. The sample consisted of four experimental and four control classes, totaling 160 students (20 per class). Data collection involved both test and non-test instruments. Non-test data were obtained through interviews and Likert-scale questionnaires to assess students' experiences, while academic writing ability was evaluated through final project assessments.
Contribution	This study expands the body of knowledge by demonstrating how integrating ChatGPT and Quillbot within a PjBL framework enhances students' academic writing skills, improves engagement, and highlights both the benefits and challenges of AI-assisted learning.
Findings	The study findings revealed a significant difference in academic writing scores between the experimental and control groups. These results indicate that PjBL, supported by ChatGPT and Quillbot, significantly enhances students' ability to report on structured mini-research and improve their academic writing.
Recommendations for Practitioners	Practitioners should integrate AI tools like ChatGPT and Quillbot within a structured PjBL framework to enhance students' academic writing skills while emphasizing critical evaluation to address concerns about credibility and overreliance on AI tools.
Recommendations for Researchers	Future researchers should examine how AI-assisted writing tools impact students' ability to develop research frameworks and conduct literature reviews over extended periods, as well as investigate strategies to enhance students' critical evaluation of AI-generated content to address credibility concerns.
Impact on Society	This study suggests that integrating AI-assisted tools in education can enhance academic writing proficiency, promote digital literacy, and improve accessibility, ultimately preparing students for a technologically evolving society.
Future Research	Future research should investigate the long-term impact of AI-assisted writing tools on students' critical thinking, originality, and independent writing across diverse academic disciplines.
Keywords	higher education, scientific writing, AI-based tools, ChatGPT, Quillbot

INTRODUCTION

Writing ability is an essential component of language proficiency, warranting attention due to its significant impact on various aspects of life (Ventura et al., 2020). While basic writing proficiency is typically established by late adolescence, higher-order writing skills, such as critical analysis, argumentation, and academic composition, require continued development through higher education and professional practice. Acquiring strong writing skills begins with early exposure to reading and structured

writing activities. Through academic writing, students are expected to convey information, generate new knowledge, present ideas, and communicate research findings (Scholz, 2022).

A preliminary study conducted by researchers as part of the 2024 “Strategies for Writing and Publishing Scientific Papers” course revealed gaps in students’ writing proficiency. Among 189 enrolled students, only 46% met the criteria for “Clarity in Problem Statement” within the introduction. In other key aspects, 56% demonstrated “Clarity in Literature and Appropriateness of References,” 60% met the standards for methodology, and 52% achieved proficiency in presenting results, ensuring analytical precision, and establishing connections between findings and fundamental concepts. These findings highlight a broader issue: the relationship between literacy and writing proficiency. Literacy extends beyond reading comprehension; it encompasses critical thinking, the ability to synthesize information, and articulate ideas clearly, skills essential for academic writing. In Indonesia, challenges in writing ability may stem from several factors, including limited exposure to structured academic writing, a stronger emphasis on rote learning over analytical composition, and the predominance of non-English academic discourse, which complicates engagement with global scientific literature.

Addressing these challenges requires a well-structured writing program that can be continuously evaluated, along with supportive tools to enhance motivation and skill development. In this regard, integrating natural writing with artificial intelligence (AI) presents valuable opportunities for improving scientific writing skills. Given the significant role of scientific writing in academic and research domains, it is essential to develop students’ ability to construct logical arguments, organize information effectively, and express ideas clearly. However, not all students and researchers inherently possess these skills, further complicating the learning process and underscoring the need for effective instructional approaches. The integration of AI tools, such as ChatGPT and Quillbot, raises concerns about potential overreliance, which could lead to a decline in reading habits and a weakening of independent writing skills. While AI can assist in refining language, improving coherence, and offering structural suggestions, it should be viewed as a complement to, rather than a replacement for, critical thinking and original composition. To prevent dependency, writing programs must emphasize a balanced approach, encouraging students to engage in deep reading, draft independently, and use AI as a tool for refinement rather than content generation.

One effective approach for integrating ChatGPT and Quillbot into learning is Project-Based Learning (PjBL). PjBL is a student-centered model that emphasizes project-based exploration and skill development (Maros et al., 2023). This approach encourages students to be active, collaborative, and creative in completing projects that are both real and relevant to their lives. Through PjBL, students not only develop conceptual understanding but also acquire practical skills in problem-solving and product creation (S. Wang, 2022), such as writing scientific papers.

The integration of AI tools into PjBL enhances the learning process by serving as an interactive tool that assists students in various stages of their writing projects. However, the integration of these tools into PjBL does not replace traditional writing instruction; rather, it enhances students’ ability to navigate the scientific writing process with greater confidence and efficiency. When used responsibly, it aligns with PjBL’s core principles of active, experiential, and self-directed learning, ultimately improving students’ writing skills while maintaining their critical thinking and creativity.

This study explores the impact of ChatGPT and Quillbot on students’ ability to write scientific papers within the framework of AI-assisted PjBL. Specifically, it examines whether these tools enhance students’ writing performance, using a combination of empirical data and analysis of writing outputs.

The following section presents a review of relevant literature, identifying current challenges in academic writing, the emergence of AI-based writing tools, and the pedagogical value of integrating them into the PjBL model. This is followed by the research design, data analysis, findings, and concludes with implications for instructional practices in higher education.

LITERATURE REVIEW

As a cognitive activity closely linked to reasoning, writing is a complex skill in language learning (Klimova, 2014; Tangpermpoon, 2008). The use of language in writing reflects cognitive processes and shapes actions (Thomé-Williams & Kim, 2017). In the 21st century, writing ability is an integral component of literacy, enabling students to articulate thoughts and ideas in a format accessible to a broader audience (Warschauer, 2009). Scientific writing is crucial in academic pursuits because it fosters critical thinking, develops analytical skills, and enables effective communication of complex ideas. Mastering these skills prepares students for scholarly discourse and future research contributions (Lafferty, 2015; Van Way, 2007). Scientific writing is particularly important for students as it fosters critical thinking, enhances analytical skills, and develops their ability to communicate complex ideas effectively. Through the process of writing, students learn to structure arguments logically, synthesize diverse sources of information, and present evidence-based conclusions. These skills are essential not only for academic success but also for professional and research careers. Additionally, mastering scientific writing prepares students for future contributions to their respective fields, enabling them to engage in scholarly discourse, publish research findings, and participate in global knowledge exchange.

Several factors contribute to students' reluctance to develop scientific writing skills. These include: (1) a lack of awareness regarding the benefits and relevance of this ability in academic, research, and career contexts, which hinders motivation for further development; (2) challenges related to limited access, technological barriers, and other constraints that affect opportunities to improve writing skills; (3) insufficient guidance and support from mentors or supervisors, who play a crucial role in clarifying writing conventions, providing constructive feedback, and assisting in overcoming challenges; and (4) apprehension and lack of confidence, stemming from uncertainties about writing ability, fear of judgment, and anxiety over potential rejection or criticism (Adek et al., 2023; Obeng-Ofori, 2014).

Given these challenges in developing scientific writing skills, both pedagogical approaches, such as PBL, and technological innovations, such as AI writing tools, offer potential solutions. First, it emphasizes experiential learning ("learning by doing"), helping students systematically understand the research process from data collection to report writing. Second, PjBL fosters collaboration, allowing students to discuss and share ideas, thereby enriching their perspectives as they construct scientific arguments. Third, it promotes independent learning, as students take responsibility for their projects, ensuring discipline in completing each stage of the process (Zhang & Ma, 2023). At the same time, integrating natural writing skills with AI technology, using applications such as ChatGPT and Quillbot, presents innovative opportunities within a constructive learning environment, particularly in scientific paper writing. ChatGPT generates human-like text, assists with structuring arguments, and enhances coherence and grammar (Halaweh, 2023; Lund et al., 2023). Quillbot focuses on paraphrasing, language refinement, and improving clarity (Ho, 2022; Nazari et al., 2021). However, both tools pose risks, including overreliance, reduced creativity, and potential inaccuracies, requiring careful integration into learning contexts (Mbakwe et al., 2023; Mumtaz et al., 2023).

Previous studies have primarily focused on assessing student responses to AI-assisted writing without examining the specific assessment instruments used to evaluate scientific writing within a structured learning model, such as PjBL. The novelty of the current study lies in the introduction of a specialized program that guides students in learning and writing scientific papers as a project. This program incorporates well-designed assignments and periodic writing training, supported by ChatGPT and Quillbot. The outcome of this learning process is the submission of student-written articles to nationally accredited journals. Therefore, this study aims to evaluate whether the integration of ChatGPT and Quillbot within the PjBL model enhances students' scientific paper writing ability sufficiently for potential acceptance by international journals.

Several studies have examined the role of ChatGPT and Quillbot in education. Raad Raheem et al. (2023) found that these AI tools significantly enhance writing accuracy and fluency while reducing the time students and researchers spend on editing and revision. Their study underscores how AI-assisted writing can facilitate the creation of high-quality content with minimal effort, making it a valuable resource for academic and professional contexts. Similarly, Marzuki et al. (2023) explored the impact of AI on students' writing outcomes, particularly in terms of content development and organization, from the perspective of EFL lecturers. Their findings further support the effectiveness of AI in improving structured writing.

For Indonesian students, using ChatGPT presents both opportunities and challenges. It can help overcome common writing difficulties, such as structuring arguments, improving coherence, and expanding vocabulary, which are particularly relevant for non-native English speakers. Many Indonesian students struggle with academic writing conventions; therefore, AI tools like ChatGPT can serve as accessible learning aids to enhance their writing proficiency. However, reliance on AI must be carefully managed to ensure that students do not become passive users who merely accept AI-generated text without critical engagement. Therefore, while ChatGPT is a valuable tool, its use should be guided by an educational framework that encourages active learning and independent writing skills.

Globally, educators have integrated ChatGPT into writing instruction, for example, supporting second-language writing in the Philippines (Barrot, 2023), narrative writing in China (Zhou et al., 2023), and argumentative writing tasks like outlining and revising (Su, 2023). In Indonesia, studies have explored AI tools in various contexts, but none have systematically integrated them into a structured PjBL framework for scientific writing (Febriani et al., 2023; Marzuki et al., 2023).

While many studies highlight the benefits of AI tools for enhancing writing fluency and efficiency, few have systematically integrated them into structured pedagogical models, such as PjBL, or objectively measured their impact on scientific writing. Especially in Indonesian higher education, there is a limited amount of research on using AI to help students produce publishable scientific papers. This study aims to fill these gaps by examining ChatGPT and Quillbot within an AI-assisted PjBL framework to improve writing outcomes and higher-order skills.

Based on the gaps identified in the literature, this study addresses the following research questions:

- What is the impact of integrating ChatGPT and Quillbot within a PjBL framework on students' scientific writing performance in higher education?
- How does participation in an AI-assisted PjBL program influence students' abilities to complete key components of scientific writing, such as literature reviews, methodology formulation, and structured reporting?
- What are students' perceptions of the benefits and challenges of using ChatGPT and Quillbot to support scientific writing, particularly in terms of accessibility, writing efficiency, engagement, and concerns about the credibility and validity of AI-generated content?
- To what extent does the integration of ChatGPT and Quillbot in PjBL foster students' active learning, collaboration, and problem-solving skills during scientific writing projects?

METHODOLOGY

RESEARCH DESIGN

This study employed a mixed-method approach, with the quantitative component specifically utilizing a quasi-experimental design with a posttest-only control group model. In addition, the qualitative component was obtained through interviews with students, focusing on their views and reflections on the learning process.

SUBJECTS

This study employed purposive sampling to select participants. All participants were undergraduate students from the Guidance and Counseling study program, enrolled in the same course, *Strategies for Compilation and Publication of Scientific Papers*, across three private campuses in West Java, Indonesia. The sample consisted of four experimental and four control classes, totaling 160 students, with each class comprising 20 students.

All students in the selected classes were invited to participate in the research component associated with this study. Participation was voluntary, and students were informed both verbally and through a written information sheet about the study's purpose, procedures, and confidentiality measures. Students were given the option to decline participation or withdraw at any stage without incurring academic penalties or affecting their course grades.

TEACHING PLANS

This study was conducted during the semester of the 2023/2024 academic year as part of the course *Strategies for Compilation and Publication of Scientific Papers*. The program consisted of 16 sessions, comprising 14 learning sessions and two examinations: the Mid-Semester Examination (Session 8) and the Final Semester Examination (Session 16).

Within a limited timeframe, students conducted mini-research projects, focusing on literature-based analysis, small-scale data collection, or conceptual reviews, rather than full-scale empirical studies. The goal was to guide students through the fundamental stages of scientific writing within a manageable scope for undergraduate students. Throughout the course, students explored academic sources, including Google Scholar, SINTA (sinta.kemdikbud.go.id/journals), Academia, and ScienceDirect, under the supervision of their lecturers. The learning process was structured as follows:

- Weeks 1–4: Students selected research topics relevant to their study programs and conducted preliminary literature reviews using structured guidelines provided by the lecturer.
- Weeks 5–7: Students participated in two training sessions focused on scientific writing strategies and the integration of AI tools – ChatGPT and Quillbot – into the writing process.

During Weeks 5–7, specific instruction was provided on how to use AI tools effectively for different stages of the scientific writing process. The training covered:

Using ChatGPT for:

- 1) Generating initial outlines for scientific papers
- 2) Formulating research questions and refining problem statements
- 3) Drafting paragraphs or sections based on structured prompts
- 4) Rewriting awkward sentences to improve clarity and coherence
- 5) Generating suggestions for literature search keywords

Using Quillbot for:

- 1) Paraphrasing complex texts into simpler language while maintaining meaning
- 2) Improving sentence structure and readability
- 3) Checking grammar and stylistic consistency across drafts
- 4) Summarizing longer passages for inclusion in literature reviews

Practical examples were provided to illustrate how these tools could assist in academic writing. For instance, students were shown how to:

- 1) Input a draft research problem into ChatGPT to receive clearer alternative formulations.
- 2) Copy a paragraph from a literature review into Quillbot to enhance fluency or simplify complex wording.
- 3) Use ChatGPT to generate sample topic sentences or transitions between sections.

Students practiced these tasks during class sessions with real excerpts from their own research topics. Additionally, they were instructed on critical evaluation of AI outputs, emphasizing that AI-generated text may require further editing for accuracy and academic integrity. Lecturers provided examples of errors or misinterpretations that sometimes occur in AI responses.

Week 8 served as the Mid-Semester Examination, in which students submitted an outline and a partial draft of their paper. This submission was assessed formatively to provide feedback on topic relevance, structure, and clarity before moving into the more advanced writing phases.

From Weeks 9–14, students refined their research frameworks, participated in guided discussions, and drafted their mini-research papers. In this phase, they were encouraged to:

- 1) Use AI tools to improve drafts, but avoid copying AI-generated content verbatim.
- 2) Document how they used AI tools and reflect on their experiences as part of their project report.

Week 15 was allocated for final consultation and peer review, where students exchanged drafts and received targeted feedback from both lecturers and classmates. This session focused on refining argumentation, improving organization, and addressing any language or formatting issues prior to final submission.

Finally, in Week 16, as part of the final examination, students submitted a complete, well-structured academic article. Their submissions were assessed on content quality, organization, language use, and evidence of effective integration of AI tools.

INSTRUMENTS

This study utilized both test and non-test instruments for data collection. Non-test data were gathered through interviews and Likert-scale questionnaires. Interviews were conducted to obtain objective insights into students' experiences using ChatGPT and Quillbot in scientific writing. Questionnaires were used to assess students' perceptions of the effectiveness of these tools in enhancing their scientific writing skills within the PjBL framework (see the Appendix for the full questionnaire statements). Meanwhile, test instruments involved evaluating students' final projects (scientific articles) to measure their comprehension and proficiency in scientific writing.

The validity and reliability of the questionnaire were assessed before use. A total of 16 items were tested for validity using the Pearson product-moment correlation. All items were valid, with Pearson correlation values exceeding the critical r -value of 0.444 ($N = 20$). In addition, the reliability test showed a Cronbach's alpha of 0.735, confirming the instrument's reliability.

STUDENTS' PROJECTS

To develop scientific writing skills, students conducted mini-research projects, focusing on structured academic writing rather than full journal articles. The project emphasized writing scientific papers suitable for submission to national journals, with AI assistance from ChatGPT and Quillbot. The scope was limited to topics relevant to each student's field of study, with target journals specializing in educational studies. While publication was encouraged, the primary goal was to develop foundational research skills and structured writing techniques. Table 1 outlines the assessment weight for the final project.

DATA ANALYSIS

Qualitative data analysis was conducted descriptively and interpretatively by organizing data into meaningful units, synthesizing information, identifying patterns, determining relationships between components, and formulating logical and systematic conclusions. Meanwhile, quantitative data analysis involved hypothesis testing using a t -test, provided that the test scores were normally distributed. These analyses were performed using SPSS version 26, with a significance level set at 0.05.

Table 1. Assessment criteria and weight for final project

No.	Indicator	Criteria	Assessment weight
1.	Relevance	Suitability of paper topic within the scope of the journal/scientific program.	5
2.	Organization of paper	Language usage, clarity of paper content, and ease of understanding by readers.	5
3.	Contribution	Quality of paper in terms of ideas, originality, novelty, and uniqueness.	5
4.	Title	Precision, brevity, and clarity in describing the content of paper.	5
5.	Abstract	Concise, clear, and comprehensive explanation of the purpose and scope of the study, methods used, summary of results, and conclusions.	5
6.	Introduction	Clarity of the problem background, scope, and purpose of the study.	5
		Differences with previous studies.	5
		Contributions made.	5
7.	Literature review	Clarity of literature review and suitability of references provided.	5
8.	Methods	Appropriateness and accuracy of study methodology.	5
9.	Results and discussion	Presentation of results and validity of analysis (can be accompanied by tables and figures to facilitate understanding).	10
		Relationship between results and basic concept or hypothesis.	10
		Theoretical and practical implications of results.	5
10.	Conclusion	Essence of results and presentation.	5
		Logical and honest reasoning based on obtained facts.	5
11.	References	Adherence to the procedure for writing and referencing/citing in paper manuscript (all references should be referred to in the manuscript).	5
		Accuracy and completeness of references.	5
		Quality and currency of references.	5
Total			100

RESULTS

This section presents the findings organized according to the study's research questions, as outlined in the literature review. The results are grouped into three main areas: the effect of integrating ChatGPT and Quillbot within a PjBL framework on students' scientific writing performance; the role of AI-assisted PjBL in supporting the learning process of scientific article writing; and students' perceptions of the benefits and challenges of using ChatGPT and Quillbot, particularly in relation to writing efficiency, accessibility, engagement, and concerns over credibility.

EFFECT OF PjBL ASSISTED BY CHATGPT AND QUILLBOT ON STUDENTS' SCIENTIFIC PAPER WRITING ABILITY

The average scores of students' scientific article writing final projects are summarized in Table 2. The experimental classes scored higher in all indicators compared to the control classes. To determine whether this difference in scores is significant, a t-test was conducted.

Table 2. Average scores of students' scientific article writing final projects

No.	Indicator	Score		Score difference
		Experimental classes (N=80)	Control classes (N=80)	
1	Relevance	4.09	3.52	0.57
2	Organization of Paper	4.09	3.87	0.22
3	Contribution	4.22	3.69	0.53
4	Title	4.00	3.97	0.03
5	Abstract	3.98	3.47	0.51
6	Introduction	7.64	6.04	1.60
7	Literature Review	4.94	4.20	0.74
8	Methods	2.78	2.48	0.30
9	Results and Discussion	19.08	15.56	3.52
10	Conclusion	7.07	5.53	1.54
11	References	13.55	12.51	1.04
Total		75.44	64.84	10.60

Before conducting a t-test, a normality test was performed using the Kolmogorov-Smirnov test. The normality test results for the experimental and control classes were 0.054 and 0.064, respectively, indicating a normal distribution. Therefore, the data met the requirements for parametric analysis. The results of the t-test are presented in Table 3.

Table 3. Mean difference test results of students' final projects

Variable	$t_{observed}$	df	t_{table}	Sig.
Final Project Score (Experiment vs. Control)	2.206	316	1.649	0.012

The results show a p-value of 0.012, which is below the 0.05 threshold, indicating a significant difference in final project scores. This suggests that PjBL with ChatGPT and Quillbot enhances students' scientific writing skills.

PjBL ASSISTED BY CHATGPT AND QUILLBOT FOR SCIENTIFIC ARTICLE WRITING LEARNING

This subsection describes the implementation of PjBL assisted by ChatGPT and Quillbot. Four assignments were given to students over the course of 16 meetings (Figure 1). These assignments include selecting the topic for the final project, training in the use of ChatGPT and Quillbot, developing a research framework as part of the midterm exam, and completing a scientific article ready for journal submission for the final exam. Figure 2 provides a snapshot of a student's article along with proof of its submission to a journal.

<p>Assignment 1: Determining the Topic and Title of a Scientific Paper</p> <ol style="list-style-type: none"> 1. Identify a topic related to the study program. 2. Create a scientific paper title that is relevant to the chosen topic (format is flexible). 3. Find five journal articles to be used as primary references. 4. Write a summary for each article. 	<p>Assignment 2: Training on Using ChatGPT and Quillbot to Assist Scientific Paper Writing</p> <ol style="list-style-type: none"> 1. Students are required to undergo training on ChatGPT and Quillbot and understand their usage. 2. The lecturer will provide small tasks. <p><i>Important Note: Information provided by ChatGPT should be treated as an example or raw material for writing a paper and still requires processing and verification. ChatGPT has limitations in understanding information or events within specific time contexts.</i></p>
<p>Assignment 3: Creating a Scientific Paper Framework</p> <ol style="list-style-type: none"> 1. For the midterm assignment, create a research framework with the following structure: <ul style="list-style-type: none"> - Title - Background - Selected Method - Discussion/Content - Conclusion - Recommendations - References 2. The framework should outline only the main points of the paper. 3. Each section should contain 1–3 sentences, while the references should include summaries of 10 journal articles. 	<p>Assignment 4: Writing a Scientific Article for Submission to a National Journal</p> <ol style="list-style-type: none"> 1. Expand the framework into a complete scientific paper following the appropriate structure. 2. Review the formatting guidelines of the selected journal. 3. Adjust the paper to match the journal's template. 4. Read example articles from the journal for reference. 5. Use ChatGPT as a source of inspiration while writing. 6. Use Quillbot to paraphrase text from cited journal articles to avoid plagiarism. 7. Properly cite all journal articles used.

Figure 1. Students' assignments

(a)

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The Application of Mind Mapping Techniques in Career Planning for 11th-Grade Students at SMAN 2 Purwakarta

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Abstract
Most of the problems experienced by high school students are reaching maturity in planning future careers. This problem arises due to the confusion experienced by students in planning a career after graduating from school. The purpose of this research is to find out how the application of mind mapping techniques to students' career planning. The approach used in this research is descriptive qualitative with data collection techniques used are observation and interviews. The results of the study show that the application of mind mapping techniques to student career planning has never been carried out by counseling teachers at SMAN 2 Purwakarta in providing guidance and counseling services in class.
Keywords: Mind mapping techniques, career planning

(b)

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Figure 2. (a) Capture of student article and (b) article submission proof

STUDENTS' PERCEPTIONS OF PjBL ASSISTED BY CHATGPT AND QUILLBOT

The results of students' responses to writing a scientific paper using PjBL assisted by ChatGPT and Quillbot are presented in Table 4. The responses to ChatGPT and Quillbot under the PjBL model indicate a generally positive perception of both tools. ChatGPT received the highest rating for easy accessibility (91.00%), indicating its user-friendly interface and availability. Other highly rated indicators include providing ease in obtaining information (90.48%), fostering enthusiasm for writing (90.74%), and offering useful advice on writing topics (90.48%). However, the lowest-rated aspect was multitasking (86.11%), suggesting that while ChatGPT is beneficial for writing, it may have limitations in handling multiple tasks simultaneously.

Table 4. Student responses to ChatGPT and Quillbot under the PjBL model

Variable	Indicators	Percentage (%) N=80
ChatGPT	Easy accessibility	91.00
	Provides ease in obtaining information related to the chosen writing topic	90.48
	Engaging, and fostering enthusiasm for writing	90.74
	Time-saving in obtaining relevant information	90.48
	Multitasking	86.11
	Provides accurate information on writing topic	90.48
	Offers inspiration in determining writing topic	87.17
	Provides the best advice on writing topic	90.48
	The credibility and validity of answers cannot be fully relied on	88.09
	Presented answers are easy to understand	89.02
Quillbot	Easy accessibility	87.17
	Provides ease in paraphrasing	87.43
	Timesaving in composing text	88.49
	Assists in reorganizing writing without changing meaning	87.83
	Engaging and fostering enthusiasm for writing	89.81
	Provides inspiration in language use	87.17

Note: Questionnaire scores were based on a 4-point Likert scale and converted to percentages by comparing the average score with the maximum score (4).

Quillbot was also rated favorably, with its highest score for engaging and fostering enthusiasm for writing (89.81%), while other indicators, such as ease of paraphrasing (87.43%) and providing inspiration in language use (87.17%), received slightly lower ratings. These findings suggest that both tools are considered effective in assisting the writing process under the PjBL model, with ChatGPT being particularly valued for its accessibility and information retrieval capabilities. Quillbot is appreciated for its paraphrasing and text organization capabilities. However, some skepticism remains regarding ChatGPT's credibility and validity (88.09%), indicating that while it is a useful tool, users recognize the need for verification of its responses.

DISCUSSION

The analysis of final project scores between the experimental and control classes revealed a significant difference, indicating that PjBL assisted by ChatGPT and Quillbot significantly enhances students' ability to write scientific articles. These findings align with previous studies emphasizing the role of AI-based tools in academic writing development. Liu (2024) highlights that students perceive ChatGPT as a valuable resource, particularly in enhancing English writing proficiency. Moreover, the

use of ChatGPT in academic writing has a positive influence on the quality of students' work, as it assists in structuring arguments and enhancing clarity (J. Wang et al., 2024).

This study found that Quillbot has been recognized as a useful tool for overcoming challenges in academic writing, particularly in paraphrasing. As a previous study stated, Quillbot's automatic writing evaluation and grammar-checking features significantly improve the overall writing process (Alzubi, 2024). Ultimately, the integration of AI-based writing assistance and PjBL not only enhances student engagement but also bridges the gap between idea generation and effective academic expression.

The use of AI in the writing process, specifically ChatGPT assisted by Quillbot, had both positive impacts and shortcomings. These applications elicited diverse perspectives, ranging from user enjoyment to concerns about academic integrity (Alm & Watanabe, 2023). Student A1 from the experimental class stated:

Learning scientific paper writing with the assistance of ChatGPT and Quillbot was enjoyable and facilitated idea generation. However, I found it challenging to paraphrase effectively.

The use of ChatGPT required careful consideration of its functionality, limitations, potential, strengths, and weaknesses. It was essential to adopt the tool with a clear purpose, avoid excessive reliance, and adhere to ethical guidelines in writing and research to prevent violations (Misnawati, 2023). Complementing ChatGPT, Quillbot serves as a valuable support tool for paraphrasing cited texts. Regarding the ease of paraphrasing, Student A2 stated:

These difficulties could be solved using Quillbot, which was user-friendly and efficient in aiding task completion.

Regarding learning effectiveness, Student A3 explained:

The quantity of learning meetings conducted in the class was insufficient. The effective use with procedures for ChatGPT and Quillbot should have been introduced from the beginning.

However, apart from the positive findings, ChatGPT should be used as a supplement to a foundational understanding of the topic under discussion. While the application possesses extensive knowledge, subject matter experts must validate information through credible and reliable sources to ensure accuracy (Day, 2023). While ChatGPT, assisted by Quillbot, provided significant support, it might not comprehensively enhance all aspects of academic writing. The scientific paper writing learning program began by establishing a foundational understanding of writing principles and gradually incorporated the practical application of ChatGPT and Quillbot to support the writing process.

The study also showed the risk of plagiarism and cheating facilitated by ChatGPT's text-generation capabilities. Overreliance on ChatGPT output could reduce opportunities for meaningful dialogue between students and educators, as well as weaken essential social interactions from a pedagogical perspective (Imran & Lashari, 2023). To address these challenges, comprehensive guidelines and assessments have been developed to prevent misuse while maximizing the benefits of AI-assisted learning (Barrot, 2023; Moqbel & Al-Kadi, 2023). Consequently, students were required to independently and manually review their writing based on valid sources after using ChatGPT and Quillbot. This learning program adhered to the ethical principles of scientific writing, including avoiding plagiarism, properly paraphrasing and citing sources, and responsibly utilizing assistive tools (Hern, 2022).

Students' responses to the use of ChatGPT indicated the highest percentage in terms of ease of access. The primary reason for its integration into the learning environment was its time-saving capability, particularly for study and writing assignments, enabling more efficient task completion (Criddle & Staton, 2022). This positioned ChatGPT as a valuable tool for supporting tasks such as idea generation, topic exploration, and referencing (Southworth, 2023). However, the lowest percentage was observed in the multitasking indicator, as some students had not fully grasped how to use ChatGPT effectively. Meanwhile, responses to Quillbot were generally positive, with students finding it engaging and motivating for writing. This enthusiasm was reflected in the higher academic writing performance observed in the experimental class compared to the control class.

Additionally, the application of PjBL in learning contributes to enhancing students' scientific writing skills. In the context of writing scientific articles, PjBL supported by ChatGPT and Quillbot provides a promising framework for integrating technology to develop academic competencies. In this study, PjBL played a central role as a pedagogical approach that emphasized not only the final product – a scientific article – but also the learning process itself, encouraging active and reflective student engagement.

The primary role of PjBL is to immerse students in a continuous cycle of exploration, planning, implementation, and evaluation (Villan & dos Santos, 2023). This approach allows students to grasp the complexities of scientific writing, from identifying research topics and gathering data to analyzing findings and refining their work through revision and editing (Zubaidi et al., 2023). At each stage, tools like ChatGPT and Quillbot serve as supportive aids, streamlining the writing process while maintaining academic rigor and enhancing accuracy.

For instance, during the exploration and problem-understanding stages, PjBL encourages students to utilize ChatGPT as a brainstorming tool to expand their perspectives and gather initial references. ChatGPT can suggest research topics, clarify complex concepts, and even simulate academic discussions, all of which enhance students' critical thinking. At this stage, PjBL emphasizes the importance of in-depth investigation, training students not only to receive information from technology but also to critically evaluate and integrate it with other reliable sources.

In the planning and implementation stages, PjBL guides students in structuring their ideas into concrete steps for composing a scientific article. At this stage, Quillbot plays a crucial role in refining grammar and enhancing writing style (Kadam & Pusawale, 2023). The integration of PjBL with tools like Quillbot adds a new dimension to writing instruction, enabling students to receive direct feedback from technology (Deveci, 2018). This tool enables students to experiment with various sentence structures and language expressions, thereby fostering a deeper understanding of academic rhetoric and enhancing their overall writing proficiency.

Thus, the primary advantage of PjBL in this learning process lies in its emphasis on a holistic approach. Students are not only guided to produce well-structured writing but are also encouraged to reflect on their learning journey (Manidaki & Zafiri, 2021). This reflection is crucial in identifying challenges encountered, evaluating how technology assisted (or fell short) in overcoming these challenges, and determining strategies for future skill improvement. The positive response from students indicates that PjBL is not only effective in enhancing writing skills but also fosters a more meaningful and relevant learning experience. Students reported increased confidence in their abilities, supported by intuitive and adaptive technology. Additionally, they could observe the direct impact of each step taken, both in improving the quality of their writing and in deepening their understanding of academic concepts.

CONCLUSIONS AND RECOMMENDATIONS

This study investigated the impact of integrating ChatGPT and Quillbot within a PjBL framework to enhance students' ability to conduct mini-research and develop scientific writing skills. The findings demonstrated that PjBL assisted by ChatGPT and Quillbot significantly improved students' academic writing performance, as indicated by a statistically significant difference in final project scores between the experimental and control groups. Through a structured 16-week learning program, students were guided through four key assignments: selecting a research topic, training in AI-based tools, developing a research framework, and completing a structured mini-research report. Unlike full-length academic articles, these mini-research projects focused on fundamental aspects of research writing, including literature review, methodology formulation, and structured reporting, making them more feasible for undergraduate students within the course duration.

The results from students' responses further support the effectiveness of this approach, with ChatGPT being highly valued for accessibility (91.00%) and information retrieval (90.48%). Quillbot was particularly appreciated for fostering enthusiasm in writing (89.81%) and improving paraphrasing (87.43%). Despite these benefits, some concerns remained regarding the credibility and validity of AI-generated content (88.09%), highlighting the need for critical evaluation of AI-assisted outputs.

Beyond improving writing proficiency, this study indicates several important benefits for both students and educators. It offers an innovative, structured approach for integrating AI tools into academic writing instruction, equipping students with practical skills to leverage technology effectively in research and scholarly communication. The use of AI tools, such as ChatGPT and Quillbot, enhances writing efficiency, reduces the time spent on drafting and revision, and fosters greater engagement in the writing process. Meanwhile, the PjBL approach promotes active learning, collaboration, and problem-solving, reinforcing essential academic competencies. Additionally, AI support can be especially valuable for language learners and students who struggle with academic writing, as it improves accessibility, clarity, and coherence.

For educators and institutions seeking to implement similar approaches, this study recommends integrating AI tools, such as ChatGPT and Quillbot, into writing courses as supportive resources rather than replacements for human effort. Educators should design structured, project-based assignments that allow students to apply these technological tools while still maintaining independent thinking and creativity. It is essential to provide explicit training sessions not only on the technical use of AI tools but also on how to critically evaluate AI-generated content, thereby avoiding over-reliance and ensuring academic integrity. Clear guidelines and assessment criteria for AI-assisted writing tasks can help students understand expectations and maintain quality and originality in their work.

Future research should investigate the long-term effects of AI-assisted writing tools on students' academic skills across various subjects. While this study demonstrates that ChatGPT and Quillbot enhance writing in a PjBL framework, further studies can investigate their impact on critical thinking, originality, and independent writing. It is also essential to investigate the ethical aspects of AI use, such as plagiarism risks and over-reliance.

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APPENDIX

Questionnaire statements: Students' views on ChatGPT and Quillbot within the PjBL framework

Tools	Indicators	Statements
ChatGPT	Easy accessibility	ChatGPT is easy to access.
	Provides ease in obtaining information related to the chosen writing topic	ChatGPT makes it easy for me to find information related to my chosen writing topic.
	Engaging, and fostering enthusiasm for writing	ChatGPT is engaging and fosters my enthusiasm for writing.
	Time-saving in obtaining relevant information	ChatGPT saves me time in finding relevant information for my writing.
	Multitasking	ChatGPT helps me multitask when working on writing assignments.
	Provides accurate information on writing topic	ChatGPT provides accurate information about my writing topics.
	Offers inspiration in determining writing topic	ChatGPT gives me inspiration when deciding on a writing topic.
	Provides the best advice on writing topic	ChatGPT offers useful advice regarding my writing topics.
	The credibility and validity of answers cannot be fully relied on	I believe the credibility and validity of ChatGPT's answers cannot always be fully trusted.
	Presented answers are easy to understand	The answers provided by ChatGPT are easy to understand.
Quillbot	Easy accessibility	Quillbot is easy to access.
	Provides ease in paraphrasing	Quillbot makes paraphrasing easier for me.
	Timesaving in composing text	Quillbot saves me time when composing text.
	Assists in reorganizing writing without changing meaning	Quillbot helps me reorganize my writing without changing the meaning.
	Engaging and fostering enthusiasm for writing	Quillbot is engaging and fosters my enthusiasm for writing.
	Provides inspiration in language use	Quillbot provides inspiration for using language in my writing.

Note: A Likert scale was used (1=Strongly Disagree; 4=Strongly Agree)

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