Generative Artificial Intelligence for Supporting Scientific Writing Among Electrical Engineering Students: A Narrative Review

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The rapid development of Generative Artificial Intelligence (GenAI) has changed academic learning and writing practices in higher education. For electrical engineering students, scientific writing is a supporting competence because technical knowledge must be communicated through laboratory reports, project documentation, proposals, final projects, and scientific articles. This narrative review examines how GenAI can support scientific writing, identifies benefits relevant to electrical engineering students, analyzes risks, and formulates principles for responsible use. The review incorporated an updated search and verification of recent empirical studies, reviews, and policy guidance, with emphasis on publications from 2023–2026. The evidence indicates that GenAI can assist ideation, brainstorming, outlining, language revision, feedback, and exploratory learning. Engineering studies also report perceived gains in learning efficiency, initiative, creativity, and writing support. However, substantial concerns remain regarding inaccurate outputs, fabricated or erroneous references, overreliance, reduced metacognitive engagement, and academic-integrity risks. In electrical engineering, these risks are amplified because errors in equations, parameters, component specifications, standards, or simulation interpretations can propagate into technical conclusions. This review proposes a Human-Led, AI-Assisted, Evidence-Verified (H-A-E) conceptual model in which students retain responsibility for problem formulation, evidence selection, critical evaluation, technical verification, scientific argumentation, authorship, and final decisions. GenAI is positioned as a cognitive and linguistic assistant, not as a source of scientific evidence or a substitute for engineering judgment.

Keywords: Academic Integrity, AI Literacy, Electrical Engineering Education, Generative Artificial Intelligence, Scientific Writing.

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1. Introduction

Generative Artificial Intelligence (GenAI), particularly systems based on large language models, is rapidly evolving in higher education because it is capable of interactively generating, transforming, summarizing, explaining, and revising text. UNESCO emphasizes that the use of GenAI in education must be human-centered and take into account ethics, privacy, security, equity, and meaningful use [1]. A mapping study in the fields of engineering and computing education also indicates that the integration of GenAI is linked to the development of AI literacy, learning support, and new pedagogical practices that require reflective and evidence-based implementation [2].

Scientific writing plays a crucial role for electrical engineering students, as technical competencies must be communicated through lab reports, project documentation, design proposals, final projects, research reports, and scientific articles. Thus, engineering education requires students not only to produce accurate technical results but also to construct well-reasoned arguments, select appropriate evidence, document procedures, interpret results, and clearly communicate technical information.

GenAI offers several opportunities in this process. Students can use it to generate potential research questions, brainstorm ideas, develop an outline, refine language, identify weaknesses in drafts, or obtain preliminary explanations. Research on engineering students shows that GenAI is used for ideation, brainstorming, communicating with instructors, bridging non-technical knowledge gaps, and optimizing design solutions [5]. Another empirical study shows that students can use GenAI to help with argument organization, structure, coherence, syntax, diction, and grammar, but still face issues regarding author voice and the loss of some of the learning experience [12].

In the Indonesian context, recent studies also show a similar pattern. Research on college students in Indonesia found that ChatGPT is widely used for writing papers, summaries, understanding concepts, and correcting grammar, while students also expressed concerns about plagiarism, dependency, misinformation, and privacy [15]. Another study on graduate students in Indonesia revealed a relatively high level of AI literacy, but there is still room for improvement in terms of motivation and ethical considerations [16]. A recent intervention study involving Indonesian students also reported improved academic writing performance following GenAI-assisted learning, although the lack of a control group in the study's design calls for cautious interpretation [14].

At the same time, GenAI output cannot be equated with scientific evidence. Language models can generate eloquent but inaccurate statements, as well as fabricated or bibliographically incorrect references. Walters and Wilder analyzed 84 articles with 636 citations generated by ChatGPT and found a high rate of false citations, including 55% for GPT-3.5 and 18% for GPT-4; even genuine citations still contained substantive errors [6]. Therefore, source verification must be treated as a core part of the writing process, not merely a final check.

The engineering context adds a more specific layer of risk. A study of 148 engineering students found positive perceptions regarding learning efficiency, initiative, and creativity, but also revealed concerns about the accuracy and reliability of GenAI outputs [7]. In electrical engineering, errors in equations, units, component parameters, control principles, circuit interpretation, standards, or simulation results can invalidate technical arguments even if the generated prose appears academic.

The integration of GenAI into academic writing must also be linked to Indonesian language learning for engineering students. The use of GenAI should not be limited to sentence correction but should be directed toward evidence-based scientific communication. Students need to be trained to distinguish between linguistic assistance and intellectual contributions, check for fidelity of meaning when paraphrasing, maintain the author's voice, and verify technical terms against disciplinary sources. Thus, language learning can serve as a gateway to developing both scientific writing competencies and responsible AI literacy. Findings from a study on AI-integrated academic writing guidelines at Indonesian universities also highlight the importance of structured guidelines that combine writing practices, learning objectives, and the critical use of AI [17].

The research gap discussed in this review is not the absence of research on GenAI, writing, or engineering education in isolation. The gap lies in the need to integrate four dimensions into a single operational educational framework, namely: (1) GenAI-assisted scientific writing, (2) electrical engineering learning needs, (3) AI literacy and academic integrity, and (4) technical verification. Based on these gaps, this review addresses three research questions: RQ1) How can GenAI support scientific writing in higher education? RQ2) What are the benefits and relevant usage patterns for electrical engineering students? and RQ3) What risks and principles should guide the responsible use of GenAI in scientific writing for electrical engineering education?

The contribution of this article is a conceptual synthesis in the form of the Human-Led, AI-Assisted, Evidence-Verified (H-A-E) model, which integrates GenAI into the scientific writing workflow while maintaining human responsibility for evidence, technical reasoning, authorship, and final decisions.

2. Method

A. Design and Scope of the Review

This study employs a narrative literature review. This design was chosen because the study's objectives are integrative and conceptual: the evidence is drawn from heterogeneous empirical studies, systematic or scoping reviews, educational interventions, and policy guidelines that are not intended for statistical meta-analysis. The structure of the review is reinforced by the SANRA principles, which emphasize clarity regarding the topic and objectives, transparency in the literature search, accuracy of references, scientific reasoning, and the presentation of relevant results [4].

B. Literature Identification and Updates

The literature search was updated throughout the manuscript's preparation using accessible academic records and publisher platforms. The search sources were therefore not limited to a single database; bibliographic details were verified against the publisher's website or DOI records, when available. The search terms were combined as follows: "generative artificial intelligence" AND "academic writing"; "generative AI" AND "higher education"; "ChatGPT" AND "scientific writing"; "generative AI" AND "engineering education"; "AI-assisted writing" AND "university students"; and "generative AI" AND "academic integrity." Priority was given to publications from 2023–2026 because GenAI capabilities and educational practices are changing rapidly.

The collection of evidence was not treated as a systematic review corpus, and no numerical screening flowchart was created or formally documented. Instead, the filtering process followed three explicit decision points: relevance to at least one research question, verifiability of the bibliographic record, and direct usefulness for the synthesis. Sources that passed these checks were then classified according to their evidentiary role (empirical study, review, intervention study, or policy/guidance) and mapped to the analytical dimensions described below. Table 1 reports the core sources that made the largest contribution to the synthesis. This procedure makes the basis for inclusion visible without presenting the narrative review as a systematic review or implying numerical completeness.

C. Inclusion and Exclusion Criteria

Sources were included if: (1) they discussed GenAI or large language models in higher education; (2) they examined academic or scientific writing, technical education, AI literacy, learning, or academic integrity; (3) they had identifiable bibliographic information; and (4) they contained findings or arguments that could be linked to at least one research question. A source is excluded if it is irrelevant to the research questions, lacks sufficient bibliographic information to be verified, or does not provide evidence that can be used in the synthesis.

D. Evidence Extraction and Thematic Synthesis

The evidence was organized into six analytical dimensions: (1) ideation and brainstorming; (2) writing and language support; (3) learning benefits and academic literacy; (4) AI literacy and student–AI interactions; (5) hallucinations, reference reliability, dependency, and academic integrity; and (6) technical verification in engineering education. For each core source, the following are documented: research design, population or corpus, key findings, quantitative evidence (if available), and its relevance to electrical engineering.

For traceability, each core source was retained in the synthesis only when its reported findings could be connected to a specific analytical dimension and at least one research question. The resulting source-to-theme relationship is reflected in Table 1 and is carried forward into the Results and Discussion through explicit source attribution.

E. Principle of Verification of Evidence

A key methodological rule in this study is that statements generated by AI are not used as evidence. Claims in the manuscript are linked to published studies, review articles, or policy documents, while numerical findings are retained only if reported in the original source. This principle is crucial because empirical research shows that GenAI can generate false citations and substantive bibliographic errors [6].

Table 1. Core Evidence and Its Role in the Review Synthesis

Source	Design	Focus	Main Evidence	Implication
Dai (2025)	Natural experiment (n=403)	GenAI in design	59.80% substantial use	Benefits are context-dependent
Fan et al. (2025)	Survey (n=148)	Learning and performance	Efficiency 88.52%; inaccuracy 62.16%	Benefits coexist with accuracy risks
Kim et al. (2026)	Interaction study (n=36)	AI literacy	High literacy supports planning and evaluation	Interaction quality is critical
Walters & Wilder (2023)	Controlled studies (84 articles)	AI errors	Fake citations: 55% GPT-3.5; 18% GPT-4	Verify AI-generated references
Álvarez Ariza et al. (2025)	Scoping review (146 studies)	Engineering education	Maps benefits, practices, and risks	Integrate discipline-specific AI literacy
Gabay et al. (2025)	Scoping review (25 studies)	Academic writing	Use spans planning to revision	AI should augment authorship
Wang (2025)	Phenomenological (n=6)	Writing process	Supports brainstorming, structure, and language	Preserve author voice
Mahapatra (2024)	Mixed-methods (n=72)	Formative feedback	Significant writing improvement	User training enhances benefits
Sanzain et al. (2026)	Pre-experimental (n=25)	Indonesian writing	Z=-4.374; p<0.001	Potential shown; causality uncertain
Hermawan & Firnanda (2025)	Survey (n=272)	ChatGPT use	Academic use alongside plagiarism/misinformation concerns	Need literacy and ethical policies

Table 2. Responsible GenAI Use in Electrical Engineering Scientific Writing

Writing Stage	Appropriate Role of GenAI	Student Responsibility	Verification Requirements
Problem Formulation	Generate candidate topics, questions, or perspectives	Select a meaningful, feasible, and technically relevant problem	Check alignment with course/research objectives and the literature
Evidence Discovery	Suggest keywords, concepts, or types of sources	Find and read the original publications	Verify the authors, title, journal, year, DOI, and actual content
Outline Development	Propose section structures and alternative arguments	Determine the logical structure and contribution	Ensure that every major claim is supported by appropriate evidence
Drafting	Suggest wording, transitions, or alternative formulations	Maintain intellectual ownership and technical meaning	Check terminology, equations, units, and claims
Revision	Identify issues in clarity, grammar, coherence, or weaknesses	Critically accept or reject suggestions	Compare revisions with the source evidence and original reasoning
Technical Analysis	Explain concepts or offer preliminary interpretations	Perform engineering reasoning and calculations	Use textbooks, articles, standards, datasheets, validated software, experiments, or reproducible simulations
Finalization	Polish language and provide checklist support	Approve the final manuscript and disclose AI use if required	Conduct human verification of content, references, ethics, and authorship

3. Results And Discussion

A. GenAI as a Tool for Ideation and Brainstorming

Evidence from engineering education indicates that ideation and brainstorming are recurring uses of GenAI. Dai reports that engineering students use GenAI for idea generation and brainstorming, while non-users identify limitations in output quality, task mismatch, adaptation or prompting skills, and unclear personal-development benefits [5]. The empirical finding therefore concerns engineering students generally, rather than electrical engineering scientific-writing courses specifically. The present review extends that evidence conceptually to electrical engineering writing by treating GenAI-generated ideas as candidate inputs whose value depends on the task and the student's ability to evaluate them.

On the basis of these findings, the conceptual synthesis of this review is that AI-generated ideas should be treated as candidates rather than conclusions. Students remain responsible for deciding whether a topic is researchable, technically meaningful, sufficiently novel, discipline-appropriate, and supported by literature. Dewi reports that Indonesian students perceive ChatGPT as helpful for overcoming writer's block and generating ideas [18]. Applying this principle to electrical engineering is a conceptual extension, particularly for alternative designs, research variables, system architectures, control strategies, and experimental questions; direct causal evidence for these specific applications was not established by the reviewed studies.

B. GenAI as a Writing and Language Assistant

Evidence from writing-process research shows that GenAI can support outlining, sentence revision, paragraph organization, clarity, coherence, syntax, diction, and grammar [12]. Mahapatra's intervention study further reports that ChatGPT can function as a formative feedback tool when learners receive

adequate training [13]. These findings directly support the writing-assistance component of the review, although the populations and writing contexts are broader than electrical engineering.

The synthesis drawn from these findings is that linguistic assistance should not be equated with transfer of authorship. Research on Indonesian EFL students highlights the importance of authenticity, author voice, and human evaluation [19]. Accordingly, the H-A-E model places student-generated reasoning and drafting before AI feedback and requires human evaluation before revision. This sequence is a conceptual recommendation derived from the cited evidence, not a directly tested intervention among electrical engineering students.

C. Relevant Benefits for Electrical Engineering Students

Within the reviewed evidence, the clearest quantitative findings specific to engineering education come from Fan et al.'s study of 148 engineering students: 88.52% reported increased learning efficiency, 64.19% increased initiative, and 58.78% a positive perception of creativity [7]. These are self-reported perceptions from engineering students and should not be generalized to measured academic performance or specifically to electrical engineering writing outcomes.

Dai provides complementary evidence that engineering students use GenAI for brainstorming, communication with instructors, filling non-technical knowledge gaps, and design optimization [5]. Pensky et al. report improvements in writing productivity and assignment quality following guided instruction among graduate students, while emphasizing the role of training and context [21]. Together, these findings support the interpretation that GenAI may function as a support layer around technical learning. Extending that interpretation to electrical engineering scientific writing remains conceptual because the cited studies do not establish a direct causal effect in that specific setting.

D. AI Literacy and the Quality of Human–AI Interactions

AI literacy should be viewed as an academic competency, not merely an additional technical skill. A scoping review of engineering and computing education identifies AI literacy as a key component of GenAI integration [2]. Studies on student–GenAI interactions show that students with higher AI literacy exhibit collaborative patterns in planning and evaluation, and these interaction patterns are associated with differences in writing performance regarding content, structure/organization, and expression [8].

Yundayani et al. identified two functional groups of AI assistance among 157 college students: ideation support and writing-quality enhancement, covering content development, organization, linguistic accuracy, coherence, cohesion, and stylistic clarity [22]. Based on this evidence, the review synthesizes a curriculum emphasis on prompt formulation, source verification, output critique, uncertainty recognition, meaning-preserving paraphrasing, author voice, and disclosure of AI use when required. These curriculum implications are proposed as an educational synthesis rather than as outcomes already validated in electrical engineering programs.

E. Hallucinations and Invalid References

Reference reliability is a documented limitation of GenAI. Walters and Wilder analyzed 84 articles and 636 citations generated by ChatGPT and reported fabricated citations of 55% for GPT-3.5 and 18% for GPT-4, while also identifying substantive errors in genuine citations [6]. Indonesian college students likewise reported misinformation as a concern in academic use of ChatGPT [15]. These findings directly support the verification principle of the H-A-E model. The resulting methodological synthesis is that AI output should not be treated as evidence. Students should locate the original publication, verify its existence and bibliographic metadata, read the relevant sections, and determine whether the source actually supports the claim. The same verification logic is extended conceptually to technical claims: explanations of circuits,

equations, components, control laws, or simulation results should be treated as preliminary interpretations that require authoritative or reproducible verification.

F. Dependency, Metacognition, and Academic Integrity

Writing-process studies indicate a tension between the benefits of improved text and the possible loss of learning experience or authentic voice when students rely heavily on GenAI [12], [19]. The present review interprets this evidence as a risk to be managed when GenAI is used for activities that academic writing is intended to develop, including problem formulation, evidence selection, reasoning, synthesis, and revision. This is an interpretive synthesis rather than a measured finding of reduced metacognition specifically among electrical engineering students. Van Niekerk et al. describe critical analysis of AI-generated texts as a pedagogical response to GenAI use [10]. Kofinas, Tsay, and Pike also report that evaluators generally cannot reliably distinguish assignments with and without GenAI input, indicating that authentic assessment alone may be insufficient [11]. From these findings, the review proposes that electrical engineering assessment can additionally document process evidence—problem formulation, source selection, calculations, design decisions, technical validation, revision history, and AI-use reflection. This assessment recommendation is a conceptual extension to the electrical engineering context, not a directly tested intervention in the reviewed evidence.

G. Technical Verification as a Distinctive Requirement in Electrical Engineering

Technical verification is the main disciplinary refinement proposed by this review. The engineering evidence establishes that accuracy and reliability are concerns in GenAI use [7], while the engineering-education literature emphasizes the need for discipline-specific AI literacy [2]. The additional focus on equations, units, boundary conditions, component specifications, standards, tolerances, algorithms, simulation settings, and experimental measurements is therefore a conceptual specification for electrical engineering scientific writing rather than a directly measured outcome of the cited studies. The proposed verification hierarchy is a conceptual synthesis: peer-reviewed literature and authoritative textbooks are used for theoretical claims; standards and official technical documentation for normative or compliance claims; manufacturer datasheets for component specifications; validated engineering software documentation for tool behavior; and reproducible measurements or simulations for system-performance claims. GenAI may help interpret these materials, but the cited literature does not support replacing them with AI-generated output.

H. The Human-Led, AI-Assisted, Evidence-Verified Conceptual Model

A synthesis of the evidence supports the Human-Led, AI-Assisted, Evidence-Verified (H-A-E) conceptual model. The seven stages below are not presented as seven empirically validated steps. Rather, they are a traceable conceptual synthesis: evidence on task-dependent GenAI use informs problem identification and assistance [5]; writing-process and feedback studies inform assistance, evaluation, and revision [12], [13], [19]; evidence on AI literacy informs critical human–AI interaction [2], [8], [22]; reference-reliability findings inform evidence verification [6], [15]; and engineering-specific accuracy concerns inform the technical-verification refinement [7]:

1. Human problem identification — students define the engineering problem, objectives, scope, and research questions.
2. Evidence gathering — students search for and read authoritative literature, standards, datasheets, and other relevant evidence.
3. GenAI assistance — GenAI is used selectively for brainstorming, outlining, language revision, feedback, or preliminary explanations.

4. Human critical evaluation — students assess the relevance, feasibility, completeness, and consistency of AI suggestions.
5. Technical verification — equations, parameters, specifications, standards, calculations, and simulation interpretations are checked against authoritative or reproducible evidence.
6. Scientific argumentation and revision — students construct arguments, integrate evidence, interpret findings, and revise the manuscript.
7. Authorship and human accountability — students approve the final manuscript, ensure citation integrity, disclose AI use when required, and accept responsibility for the submitted manuscript.

In summary, the model can be represented as follows: Problem Identification by a Human → Evidence Collection → GenAI Assistance → Critical Evaluation by a Human → Technical Verification → Scientific Argumentation and Revision → Human Authorship → Final Manuscript. The model is guided by three principles. First, human-led: students identify the problem, gather evidence, apply reasoning, and make the final decision. Second, AI-assisted: GenAI supports specific tasks without replacing the learning process. Third, evidence-verified: key claims are checked against original, authoritative, or reproducible evidence. The mapping above also clarifies the boundary between evidence and interpretation. The cited studies provide the empirical or review-level findings; the sequence, labels, and integration of those findings into the H-A-E workflow constitute the author's conceptual synthesis. Consequently, the model should be read as a framework for implementation and future testing, not as an empirically established causal model.

I. Implications for Education and Assessment

In electrical engineering programs, GenAI literacy should be integrated with technical literacy and scientific writing literacy. Instructors can require students to submit not only a final report but also an evidence map, a list of selected sources, records of calculations or simulations, a revision history, and a brief statement explaining how GenAI was used. This approach makes students' reasoning more transparent and reduces the incentive to outsource the entire assignment to AI. Instructors can also use GenAI critically, rather than simply banning it. Students can be asked to compare AI explanations with textbooks or datasheets, identify technical errors, correct false references, or test AI-generated technical claims through simulations or experiments. This approach transforms known risks into learning opportunities and aligns with findings that critical evaluation skills can be taught through active engagement with AI-generated text [10].

J. Limitations of the Review

This review has several limitations. First, its design is narrative rather than systematic; sources were selected based on explicit relevance, bibliographic verifiability, and evidentiary contribution, but a registered systematic-review protocol and numerical screening log were not used. Second, the search relied on accessible academic records and publisher platforms rather than a fully documented database-specific retrieval log; therefore, the review does not claim exhaustive retrieval or reproducible database counts. Third, GenAI systems and educational practices are evolving rapidly, so the findings may become outdated as model capabilities and institutional policies change. Fourth, direct evidence specifically focused on electrical engineering academic writing remains more limited than evidence on engineering education and higher education in general. Fifth, several educational recommendations are conceptual extensions from engineering education, academic writing, and AI-literacy research rather than direct causal evidence from electrical engineering writing courses. Sixth, the H-A-E model is a conceptual synthesis and still requires empirical validation through experiments, mixed-methods studies, or longitudinal research on electrical engineering students.

4. Conclusion

The reviewed evidence indicates that GenAI has potential to support scientific writing and learning activities among electrical engineering students, particularly in ideation, brainstorming, outlining, language revision, feedback, exploratory learning, and specific design support. Empirical evidence in engineering points to perceived improvements in learning efficiency, initiative, and creativity, while studies of the writing process indicate that benefits depend on task characteristics, student abilities, training, and context. These findings should not be generalized as proof of improved academic performance or as direct causal evidence for electrical engineering writing courses. However, the evidence consistently supports the need for critical evaluation, source verification, and responsible human oversight. Hallucinations, fabrications or misreferences, dependency, reduced cognitive engagement, and academic-integrity risks remain important concerns. In electrical engineering, inaccurate outputs can have additional consequences because errors in equations, parameters, specifications, standards, or technical interpretations can propagate into calculations, designs, simulations, and conclusions. This article therefore proposes the Human-Led, AI-Assisted, Evidence-Verified (H-A-E) conceptual model. In this model, students remain responsible for problem formulation, evidence selection, critical evaluation, technical verification, scientific argumentation, authorship, and ultimate accountability. The model is a conceptual synthesis that should be empirically tested rather than treated as a validated intervention. Future research should assess its effects on writing quality, technical accuracy, metacognitive engagement, AI literacy, and academic integrity among electrical engineering students.

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