Using Generative Artificial Intelligence to Advance Student Mastery of IEEE Format

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In the field of electrical and computer engineering (ECE), IEEE format [1] represents the prevailing convention for technical reports, conference papers, and journal publications. Since much of the literature ECE students typically encounter is prepared in IEEE format, familiarity with that format helps them engage effectively with the literature and contribute to it. Consequently, mastery of IEEE format is expected for graduates from ECE programs. This expectation is further codified by ABET Criterion 3 (Student Outcomes), which requires that graduates attain "an ability to communicate effectively with a range of audiences," in both professional and technical contexts [2]. Most ABET-accredited ECE programs adopt IEEE formatting standards to achieve this communication outcome.

IEEE format features a standardized document structure, numbered equations, and consistent treatment of figures, tables, and references. Those features are designed to promote clarity, precision, and efficiency in presenting complex engineering content. Learning IEEE format helps students strengthen their precision and clarity in technical writing. However, many undergraduate ECE students find the conventions in IEEE format difficult to master [3-4]. One common practice in many ABET-accredited ECE programs is to offer a dedicated technical writing course that explicitly teaches IEEE conventions. Then, students are expected to use their learned IEEE conventions in other courses in the curriculum. While this curricular model can yield measurable benefits to students [4-5], its success depends on sustained reinforcement. Based on classroom experience in upper-division (junior- and senior-level) ECE courses, it has been evident that some students continue to have difficulty applying IEEE format accurately in their project reports, even after completing the required technical writing course. This recurring pattern suggests the value of a tool that can provide ongoing support as students work to apply IEEE format consistently.

Generative artificial intelligence (AI) offers one possible way to support students' learning of IEEE format. When OpenAI released ChatGPT in November 2022, many discussions in higher education focused on concerns about academic integrity. Some institutions take a strict prohibition stance, as seen in a publicly reported case: a doctoral student at the University of Minnesota was expelled after being accused of using AI on a written preliminary exam, an allegation the student disputes and has challenged in court [6]. Different from the prohibitive stance, in recent years, researchers have also explored how AI tools can be used constructively to support learning [7]. Recent studies have reported that AI-supported formative feedback helps students adhere to disciplinary writing conventions and support transfer if technical communication skills, especially when used alongside instructor guidance [8–9].

Objectives

This study investigates whether increased access to generative AI tools, such as ChatGPT, is associated with undergraduate ECE students' actual use of these tools in completing project reports. It also examines whether increased access to and autonomous use of generative AI tools have influenced undergraduate ECE students' ability to correctly apply IEEE-format conventions in course project reports. In addition, the study explores how AI tools can be purposefully integrated into undergraduate ECE curricula to support students' understanding and application of in-text citations and references, figures and tables, equations, and IEEE-format document structure.

Method

Design and Sample

Sixty-seven anonymized student project reports were collected from an undergraduate senior-level Control Systems course in two academic terms: Spring 2022 and Spring 2025. Of the 67 project reports, 36 are from the spring 2022 semester and 31 are from the spring 2025 semester. The Spring 2022 cohort represents a baseline condition, prior to the public availability and widespread use of ChatGPT, whereas the Spring 2025 cohort represents a post-ChatGPT condition, during which students had increased access to and were more likely to autonomously use generative AI tools in their academic work.

AI-use Detection Procedure

To investigate whether increased access to generative AI tools was associated with actual use (Objective 1), each project report was analyzed using an AI-detection feature available through Grammarly. Because the study employed a retrospective non-equivalent groups design based on archival data, it was not feasible to administer follow-up surveys to determine students' AI use at the time the reports were written. The AI-detection tool was therefore used as an indirect indicator of potential AI-generated text within each report. The proportion of project reports flagged as containing likely AI-generated content was reported for the baseline and post-ChatGPT conditions.

Measures

All project reports were re-evaluated exclusively for IEEE format compliance. Two independent raters evaluated each project report using a 3-point Likert-type of scale (1 = little evidence of compliance, 2 = some evidence of compliance, 3 = much evidence of compliance) to determine the extent to which IEEE-format conventions were correctly applied. The scale was treated as ordinal in subsequent analyses. Interrater reliability was assessed using quadratic weighted Cohen's kappa. The resulting coefficient indicated substantial agreement between raters ($\kappa = .66$).

In addition to numeric ratings, the raters recorded written comments for each project report. These comments identified specific IEEE formatting issues related to equations, figures and tables, citations and references, and required structural elements. The evaluation was limited to IEEE-format compliance and did not consider technical content.

Data Analyses

A single compliance score was derived for each project report by computing the median of the two raters' scores. This approach preserved the ordinal nature of the scale while providing one representative rating per project report for subsequent analyses. Descriptive statistics were computed for each condition to summarize students' performance on IEEE-format compliance. To examine whether students' ability to correctly apply IEEE-format conventions differed between the baseline condition and the post-ChatGPT condition, a Mann–Whitney U test was employed. In addition, Cliff's delta was calculated to estimate the magnitude of the difference between conditions as a nonparametric effect size. Cohen's d was also computed.

Written comments were analyzed using qualitative content analysis to identify recurring patterns of IEEE-formatting deficiencies. The resulting patterns informed the development of a student-oriented IEEE-format checklist and the design of targeted AI prompts intended to provide formative guidance on commonly observed formatting challenges. In this way, the qualitative analysis directly supported the study's second objective by grounding the purposeful integration of AI tools in observed student needs.

Results

AI-detection Outcomes by Condition

AI-detection analysis indicated no instances of AI-generated text in the baseline condition (0 of 36 project reports). In contrast, 10 of 31 project reports (32.3%) in the post-ChatGPT condition were flagged by Grammarly's AI-detection feature as containing some AI-generated text. Among the 10 flagged reports, the proportion of text identified as potentially AI-text ranged from 3% to 42%, with a mean of 19.4% (SD = 13.5%).

The flagged text was most commonly located in the introduction (5 reports) and conclusion (5 reports). Less frequently, flagged segments appeared in the design process section (2 reports), the results section (1 report), and the title (1 report). These counts are not mutually exclusive, as some reports contained flagged text in more than one section. These distributions suggest that AI-text patterns were more likely to appear in narrative sections than in technical portions of the project reports.

Overall IEEE-Format Compliance by Condition

The descriptive statistics for the IEEE-format compliance ratings were summarized in Table I. For the baseline condition, the mean rating was 1.68 and the median was 1.5. For the post-ChatGPT condition, the mean rating was 1.65 and the median was 1.5. Standard deviations were comparable across conditions (0.60 for baseline and 0.66 for post-ChatGPT), indicating similar variability in evaluator judgments.

Table I: Descriptive statistics for IEEE compliance ratings

Condition	**Mean**	**Median**	**Std. Dev.**	**n**
Baseline	1.68	1.5	0.60	36
Post-ChatGPT	1.65	1.5	0.66	31

A Mann–Whitney U test was conducted. The analysis indicated no statistically significant difference between the baseline condition and post-ChatGPT condition ($U = 587.50$, $p = 0.71$). The nonparametric effect size, Cliff's delta, yielded a value of $\delta = 0.05$, which indicated minimal practical difference between conditions.

Patterns of IEEE-Formatting Deficiencies

Analysis of written comments revealed consistent patterns of IEEE formatting deficiencies across both conditions. The most frequently identified issue was missing equation numbering, which appeared in the majority of reports. Additional recurring issues included missing or improperly formatted figure and table captions, failure to reference figures within the text, and omission of required elements such as a conclusions section.

While similar issues were observed in both conditions, reports from the post-ChatGPT condition more frequently exhibited multiple IEEE-formatting violations within the same report. Reports receiving low ratings typically exhibited multiple concurrent deficiencies spanning equations, figures, citations, and document structure. In contrast, median-rated reports generally exhibited more isolated formatting issues, while high-rated reports often contained equation numbering errors.

The proportion of project reports exhibiting major IEEE-formatting issues, as identified in evaluator comments is summarized in Table II. These recurring patterns served as the basis for developing a student-oriented IEEE-format checklist and for defining the focus areas of targeted AI prompts addressing the most frequently observed formatting challenges.

Table II: Proportion of project reports exhibiting major IEEE formatting issues by condition

IEEE Formatting Issue	**Baseline (n = 36)**	**Post-ChatGPT (n = 31)**
Missing equation numbers	69.4%	100%
Missing or incomplete figure captions	16.7%	51.6%
Missing figure citations in text	13.9%	35.5%
Incorrect table caption placement	16.7%	0%
Missing conclusions	8.3%	48.4%
Multiple concurrent IEEE violations	27.8%	74.2%

Discussion

This study sought to examine the relationship between increased access to generative AI tools and undergraduate ECE students' use of these tools. The AI-detection results indirectly suggested that some students in the post-ChatGPT condition may have used AI tools. Most flagged text appeared in the introductory and conclusion sections. This pattern indicates that students primarily use AI tools for narrative writing rather than for technical analysis. There was little evidence that students used AI tools to improve IEEE formatting in their project reports. These findings highlight the need for clearer guidance on how AI tools can be used to support learning IEEE formatting.

Another objective of this study was to examine whether increased access to generative AI tools, such as ChatGPT, have influenced undergraduate ECE students' ability to correctly apply IEEE-format conventions in course project reports. Quantitative results indicated no statistically significant difference in overall IEEE-format compliance between the baseline and post-ChatGPT conditions. These findings suggest that generative AI tools, when accessed and used autonomously by students, are not sufficient to improve IEEE-format mastery. This interpretation aligns with prior research emphasizing that AI tools are most effective when integrated purposefully into the learning process with instructional scaffolding [8, 10].

Qualitative analysis results further corroborated the quantitative findings. Although similar categories of IEEE-formatting deficiencies were observed across both conditions, reports from the post-ChatGPT condition more frequently exhibited multiple concurrent formatting violations within the same report. This pattern suggests that students in the post-ChatGPT condition likely did not use generative AI tools effectively for checking detailed IEEE-format compliance. Prior research indicates that students most commonly use generative AI for idea generation, educational support, and general writing assistance [11]. Faculty perspectives reported in [12] similarly emphasize that generative AI functions best as a supplementary tool, and that its educational value depends on explicit instructional guidance and contextual scaffolding.

In response to the recurring IEEE-formatting deficiencies, a student-oriented IEEE-format checklist was developed to address the most frequently observed challenges. The checklist is intended to support students' self-review during report preparation and is provided in the Appendix. In addition, a sample AI prompt (see Figure 1) was developed to illustrate how AI tools may be used in a structured manner to assist students in checking IEEE-format compliance. It should be noted that the sample AI prompt is broader than what the two independent raters actually evaluated in the present study. Students may adapt the sample AI prompt to align with their specific course assignment instructions.

Prompt:

Please review the attached document for adherence to IEEE formatting standards and identify places where the format is not yet IEEE-compliant. This includes, but is not limited to:

In-text citations and reference list formatting
Reference numbering and ordering
Section and subsection headings
Figure and table captions and placement
Equation formatting and numbering
Page layout, fonts, spacing, and overall document structure

For each formatting issue you identify:
Indicate the location (section, page, or line if available)
Briefly explain what part of the IEEE format is not followed
Provide a clear example or description of the correct IEEE-compliant format

Focus only on formatting, not on technical content, ideas, or writing quality.
Do not comment on:
Technical accuracy or completeness
Grammar, spelling, or general writing style
Organization unrelated to IEEE format

Figure 1. Example AI prompt for student self-checking of IEEE-format compliance

Limitations

The following limitations should be considered when interpreting these findings. First, students' use of generative AI tools was not measured directly. AI-detection software was used as an indirect indicator of potential AI-generated text. Because such AI-detection tools rely on probabilistic models, they cannot determine with certainty whether students used AI or how they used it. Future studies would benefit from collecting direct evidence of AI use, such as student surveys, observations, or usage logs, to provide a better picture of how AI tools are incorporated into academic work.

Second, the study employed a retrospective non-equivalent groups design, which does not capture within-student development over time. Longitudinal research following the same students across multiple courses would provide stronger evidence regarding changes in IEEE-format mastery.

Finally, the proposed student-oriented IEEE-format checklist and sample AI prompt were derived from observed patterns in student work but were not empirically tested in the present study. Future research is needed to determine their effectiveness in improving students' application of IEEE-format conventions.

Conclusion

In conclusion, the increasing availability of generative AI tools represents a significant change in how students engage with technical writing in engineering education. This study contributes to our understanding of how AI use can impact students' mastery of IEEE-format. The findings indicate that increased access to AI tools alone does not lead to improved overall IEEE-format compliance, highlighting the need for guided AI use. Future research should evaluate the effectiveness of structured supports, such as IEEE-format checklists and targeted AI prompts, in improving students' implementation of professional formatting standards.

Appendix

IEEE Format Checklist

This checklist is designed as a quick self-review tool to strengthen your use of IEEE format where applicable. Before submitting your report, please check the following **IEEE formatting essentials**:

Document Structure

- ☐ Title, author information, abstract, and conclusion consistent with IEEE layout
- ☐ Section headings and numbering consistent with IEEE conventions
- ☐ Use of correct column format (one-column or two-column, as required)

Citations and References

- ☐ In-text citations using **numbered brackets** (e.g., [1], [2]–[4])
- ☐ References numbered **in order of first appearance**
- ☐ Every in-text citation with a corresponding entry in the reference list
- ☐ Reference entries consistent with IEEE style for authors, titles, venues, and dates

Figures and Tables

- ☐ Figures and tables numbered consecutively
- ☐ Figure captions appearing **below** figures; table titles appearing **above** tables
- ☐ All figures and tables referenced in the text
- ☐ Fonts and labels inside figures being readable and consistent

Equations

- ☐ Equations centered and numbered consecutively
- ☐ Equation numbers appearing in parentheses and being right-aligned
- ☐ All equations being referenced in the text

Formatting Details

- ☐ Fonts, spacing, and margins matching IEEE guidelines
- ☐ Consistent use of symbols, abbreviations, and units
- ☐ Acronyms defined at first use

Final Review

- ☐ No mixing of IEEE format with APA, MLA, or other styles
- ☐ Formatting being consistent throughout the document

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