

Comparing AI-Assisted Feedback and Collaborative Digital Writing for Improving Argumentative Writing among Indonesian EFL Students

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Abstract

Digital technologies offer EFL learners new forms of feedback and collaboration in writing instruction, yet empirical evidence comparing AI-assisted feedback and collaborative digital writing remains limited, particularly in secondary-school contexts. This study compared the effectiveness of AI-assisted feedback and collaborative digital writing in improving Indonesian EFL students' argumentative writing and explored the learning experiences underlying the quantitative outcomes. An explanatory sequential mixed-methods design was employed with 37 tenth-grade students from two intact classes. Students in the AI-assisted feedback group revised their argumentative essays using Grammarly, while those in the collaborative digital writing group worked collaboratively through Google Docs. Quantitative data were analyzed using paired- and independent-samples t-tests, while interview data were analyzed thematically to explain the observed patterns. Both groups demonstrated significant improvement in argumentative writing performance, with the AI-assisted feedback group showing greater overall improvement. However, qualitative findings indicated that the two approaches supported different dimensions of writing development. AI-assisted feedback facilitated immediate revision, linguistic accuracy, and independent monitoring, whereas collaborative digital writing promoted idea generation, negotiation of meaning, peer interaction, and argument development. These findings suggest that although AI-assisted feedback produced stronger overall learning outcomes, collaborative digital writing provided complementary pedagogical benefits. Teachers may therefore select or combine digital writing approaches according to specific instructional objectives and learners' needs.

Keywords: AI-Assisted Feedback; Argumentative Writing; Collaborative Digital Writing; EFL Writing; Technology-Enhanced Language Learning.

INTRODUCTION

The ability to construct well-reasoned arguments through writing has become an increasingly important competence for English as a Foreign Language (EFL) learners, particularly as English education continues to emphasize critical thinking, evidence-based reasoning, and effective communication. Unlike descriptive or narrative writing, argumentative writing requires learners to formulate defensible

claims, evaluate supporting evidence, anticipate opposing viewpoints, and organize ideas into coherent and persuasive texts. Successfully accomplishing these tasks demands more than grammatical knowledge alone; learners must also coordinate rhetorical organization, logical reasoning, and linguistic accuracy throughout the writing process. Consequently, argumentative writing is widely regarded as one of the most cognitively demanding forms of academic writing,

requiring students to integrate multiple linguistic and cognitive processes simultaneously (Graham, 2021; Kormos, 2023). Developing these interconnected competencies has therefore become a central objective of contemporary EFL instruction, particularly at the secondary-school level where students are expected to communicate ideas critically through written texts.

Despite its importance, mastering argumentative writing remains challenging for many EFL learners, especially in contexts where English is learned as a foreign language. Recent research has shown that EFL learners may struggle to generate convincing arguments, organize ideas logically, and provide sufficient evidence to support their claims, even when they demonstrate adequate grammatical knowledge (Kormos, 2023; Teng & Yue, 2023; Geng et al., 2022). These difficulties indicate that effective argumentative writing instruction needs to address not only linguistic accuracy but also idea development, rhetorical organization, and evidence-based reasoning. Similar patterns have also been observed in Indonesian secondary education, where students frequently encounter difficulties in maintaining coherence, elaborating arguments, and balancing language accuracy with critical reasoning. As a result, writing instruction commonly places greater emphasis on correcting linguistic errors than on helping learners develop persuasive arguments and higher-order thinking skills. Addressing these challenges requires instructional approaches that extend beyond correcting language errors to actively supporting idea development, critical reasoning, and sustained revision throughout the writing process.

Responding to these challenges, writing instruction has increasingly embraced digital technologies to create more interactive, responsive, and learner-centered learning

environments. The growing adoption of Technology-Enhanced Language Learning (TELL) has transformed the way writing is taught by expanding opportunities for students to draft, revise, and refine their work beyond conventional classroom practices. Rather than functioning merely as supplementary tools, digital technologies now support various stages of the writing process, including idea generation, language revision, collaborative drafting, and reflective learning (Golonka et al., 2014; Iberahim et al., 2023). This shift reflects a broader pedagogical movement from teacher-centered feedback toward learning environments that encourage greater learner autonomy, continuous revision, and meaningful interaction. As digital platforms become increasingly integrated into English classrooms, teachers are also expected to select instructional technologies that not only improve linguistic accuracy but also facilitate the development of higher-order writing skills. Recent studies have further emphasized that the effectiveness of technology-enhanced language learning depends not only on the availability of digital tools but also on how technology is integrated into meaningful pedagogical practices that promote learner engagement and interaction (Hanafiah et al., 2022; Iberahim et al., 2023).

Among the various digital writing approaches, AI-assisted feedback and collaborative digital writing have attracted increasing attention because they support writing development through different pedagogical mechanisms. AI-assisted feedback can provide immediate responses to linguistic and textual problems, enabling learners to identify errors, revise their drafts, and monitor their writing during the composing process (Barrot, 2023; Gozali et al., 2024; Nguyen, 2026). Recent research further suggests that the pedagogical value of AI-supported feedback depends on learners' ability to interpret and act upon automated suggestions rather than simply accepting them

(Gozali et al., 2024; Haddadian et al., 2025). In contrast, collaborative digital writing provides a shared environment in which learners can exchange ideas, negotiate meaning, provide peer feedback, and jointly develop written texts (Ebadijalal & Moradkhani, 2023; Veddayana et al., 2025). These approaches therefore represent different forms of technology-mediated writing instruction, with AI-assisted feedback emphasizing individualized revision and collaborative digital writing emphasizing interaction and shared knowledge construction.

Recent research has increasingly examined AI-assisted feedback as a form of writing support that can provide learners with immediate responses to linguistic and textual problems during revision. Recent systematic reviews indicate that research on AI-supported second-language writing has expanded rapidly, particularly since 2023, with studies examining automated feedback, generative AI, learner revision, and self-regulated writing processes (Feng et al., 2025; Luo et al., 2025; Sanz-Tejeda et al., 2026). In argumentative writing, automated writing evaluation has also been examined as a means of supporting revision and improving aspects of written performance (Haddadian et al., 2025; Khatami & Suryati, 2026). These developments suggest that AI-assisted feedback may be particularly valuable when learners actively interpret and respond to feedback rather than simply accepting automated corrections.

Collaborative digital writing has likewise demonstrated considerable pedagogical value in language classrooms. By engaging learners in shared planning, drafting, and revision, collaborative writing environments encourage discussion, negotiation of meaning, and collective problem-solving throughout the writing process (Kessler et al., 2012). Such

interactions create opportunities for learners to exchange feedback, refine arguments, and co-construct knowledge, ultimately supporting both language development and higher-order thinking skills (Ebadijalal & Moradkhani, 2023). Despite these promising findings, existing studies have generally examined AI-assisted feedback and collaborative digital writing as separate instructional approaches. Consequently, relatively little empirical evidence is available regarding how these two technology-enhanced approaches compare when implemented under similar instructional conditions, particularly in Indonesian secondary-school EFL classrooms. This lack of direct comparison limits teachers' ability to make informed pedagogical decisions when selecting digital tools to support argumentative writing instruction. However, direct empirical comparisons between AI-assisted feedback and collaborative digital writing remain relatively limited, particularly in secondary-school EFL contexts.

Recent studies have increasingly examined AI-supported writing, automated writing evaluation, and collaborative digital writing independently, but fewer studies have compared these approaches under comparable instructional conditions (Gozali et al., 2024; Haddadian et al., 2025; Veddayana et al., 2025). This limitation makes it difficult to determine whether differences in writing outcomes are associated primarily with the technological tools themselves or with the different learning processes that they facilitate.

Although both AI-assisted feedback and collaborative digital writing have demonstrated considerable pedagogical potential, previous research presents findings that are not entirely consistent regarding their relative effectiveness in supporting argumentative writing development. Several

studies have reported that AI-assisted writing environments primarily improve linguistic accuracy by enabling learners to receive immediate corrective feedback throughout the drafting process (Barrot, 2023; Gozali et al., 2024; Haddadian et al., 2025). In contrast, research on collaborative digital writing has emphasized its contribution to idea generation, critical thinking, and peer-supported revision rather than immediate language accuracy (Kessler et al., 2012; Ebadijalal & Moradkhani, 2023). These differences suggest that the two instructional approaches may influence different dimensions of writing development, making direct comparison essential for understanding their respective pedagogical strengths.

Moreover, much of the existing literature has investigated these instructional approaches independently, often focusing on university students or adult language learners. Comparatively fewer studies have examined their implementation in secondary-school EFL classrooms, where students generally possess more limited writing experience and require greater instructional guidance throughout the writing process. Consequently, evidence regarding how these approaches function within Indonesian senior high school contexts remains relatively limited. Addressing this gap is particularly important because instructional decisions made by secondary-school teachers frequently influence students' early development of academic writing skills and their readiness for higher levels of education.

Technology-Enhanced Language Learning (TELL) provides a broader pedagogical perspective for understanding the role of digital technologies in language education. From a TELL perspective, the effectiveness of technology should not be determined solely by the features of a particular digital tool but by how those features mediate learning

activities, learner engagement, interaction, and feedback. Thus, AI-assisted feedback and collaborative digital writing can be understood as different forms of technology-mediated instruction rather than simply as two competing digital tools. The former emphasizes individualized and immediate feedback during revision, whereas the latter creates a shared digital environment for interaction and collaborative knowledge construction. This distinction provides a useful basis for examining why the two approaches may produce different patterns of writing development.

The AI-assisted feedback approach can be further understood through the perspective of Self-Regulated Learning (SRL). In writing, self-regulated learning involves learners' active monitoring of their performance, identification of problems, strategic revision, and evaluation of the resulting text. Immediate automated feedback can support these processes by making linguistic problems visible while students are still engaged in composing and revising. Recent research has increasingly linked AI-supported language learning with self-regulatory processes, suggesting that AI can function as a resource for monitoring and revising learning performance when learners actively interpret and act upon the feedback rather than passively accepting automated suggestions (Zhang et al., 2025; Wang, 2024). In the present study, this perspective provides a theoretical explanation for the potential of Grammarly to support students' independent revision and attention to linguistic accuracy.

In contrast, collaborative digital writing can be interpreted through Sociocultural Theory, which views learning as socially mediated through interaction with others and the use of cultural and technological tools. Writing in a shared digital environment allows learners to externalize ideas, respond to peers, negotiate

meaning, and jointly construct a text. Such interaction is particularly relevant to argumentative writing because students need to consider alternative perspectives, justify claims, and develop relationships among ideas and evidence. Recent research on digital collaborative writing has similarly highlighted the role of collaborative interaction and co-regulated learning in supporting L2 writing development (Pan & Teng, 2025). From this perspective, Google Docs functions not merely as a platform for producing a shared text but as a mediating environment in which students can construct and refine knowledge through social interaction.

Taken together, Self-Regulated Learning and Sociocultural Theory provide complementary perspectives for interpreting the two instructional approaches examined in this study. AI-assisted feedback primarily supports an individually oriented cycle of monitoring, feedback interpretation, and revision, whereas collaborative digital writing emphasizes socially mediated processes of idea development, negotiation, and co-construction. These perspectives do not imply that the two approaches operate exclusively through individual or social learning processes; rather, they highlight their dominant pedagogical affordances. This theoretical distinction is particularly useful for interpreting the present mixed-methods findings, in which AI-assisted feedback produced greater overall improvement while collaborative digital writing demonstrated complementary benefits for interaction, idea generation, and argumentative development.

Despite the growing use of AI-assisted feedback and collaborative digital writing in EFL writing instruction, empirical comparisons of these approaches within comparable instructional conditions remain limited, particularly in secondary-school contexts. Existing studies have largely

examined automated or AI-assisted feedback and collaborative writing independently, making it difficult to determine how their different pedagogical affordances relate to students' overall writing development. This issue is particularly important in argumentative writing, which requires students to coordinate linguistic accuracy with idea development, logical organization, justification of claims, and consideration of alternative perspectives. Moreover, focusing only on pre-test and post-test differences may not fully explain why one approach produces greater improvement than another. A closer examination of learners' experiences is therefore needed to identify the pedagogical processes underlying different learning outcomes.

Addressing this gap, the present study compares AI-assisted feedback and collaborative digital writing in the same secondary EFL context and combines quantitative evidence of writing improvement with qualitative evidence of students' learning experiences. The study does not assume that one technology is universally superior; rather, it investigates whether the two approaches produce different patterns of writing development and how learners perceive the processes through which those changes occur. This comparative mixed-methods perspective contributes to Technology-Enhanced Language Learning (TELL) research by shifting attention from the technological tool itself toward the pedagogical affordances and learning processes that the technology enables. The findings may provide teachers with more nuanced guidance for selecting digital writing approaches according to specific instructional objectives.

Accordingly, this study aims to compare the effectiveness of AI-assisted feedback and collaborative digital writing in improving Indonesian EFL students' argumentative

writing while examining the learning experiences associated with the observed differences in writing performance. By combining quantitative evidence of writing improvement with qualitative insights into students' learning experiences, the study seeks to provide a more comprehensive understanding of how these two technology-mediated instructional approaches support argumentative writing development. The findings are expected to contribute to research on Technology-Enhanced Language Learning and provide practical implications for English teachers in selecting digital writing approaches that correspond to different instructional objectives and learners' needs.

METHODOLOGY

Research Design

This study employed an explanatory sequential mixed-methods design to compare the effectiveness of AI-assisted feedback and collaborative digital writing in supporting Indonesian EFL students' argumentative writing development. The study began with the collection and analysis of quantitative data to examine changes in students' writing performance following the instructional intervention. The quantitative findings were subsequently complemented by qualitative data to provide a deeper understanding of students' learning experiences and to explain patterns observed in the statistical results. Integrating both forms of data enabled a more comprehensive interpretation of how the two technology-enhanced instructional approaches influenced students' argumentative writing development.

In this design, quantitative findings served as the primary source of evidence for determining the effectiveness of the two instructional approaches. The subsequent qualitative phase was conducted to explain and interpret the statistical results by exploring students' learning experiences and perceptions of the instructional interventions.

Integrating both forms of data enabled a more comprehensive understanding of how AI-assisted feedback and collaborative digital writing influenced argumentative writing development beyond numerical score improvements alone.

Participants and Research Context

The participants were 37 tenth-grade Indonesian EFL students from two intact classes at a senior high school. The students were 15-16 years old, consisting of 17 male and 20 female students. Seventeen students participated in the AI-assisted feedback group, while 20 students participated in the collaborative digital writing group. The two classes were selected as the instructional groups within the existing school context, and their baseline writing performance was assessed through the pre-test administered before the intervention. The pre-test was used to examine the groups' baseline writing performance before the intervention and to determine whether substantial differences were present at the outset of the study.

The AI-assisted feedback group used the free version of Grammarly as an automated writing feedback tool during the writing and revision process. Students independently reviewed the feedback generated by Grammarly and used the suggestions to identify and revise problems in their written texts. The feedback primarily supported language-level aspects of writing, including grammatical accuracy, spelling, punctuation, and clarity. Students were expected to evaluate the suggestions and make their own decisions about whether and how to revise their texts rather than simply accepting automated corrections. Recent research similarly indicates that automated writing feedback can support EFL learners' attention to accuracy and revision, while its effectiveness depends on how learners engage with and respond to the feedback.

In the collaborative digital writing group, students worked in randomly formed groups of four to five students using Google Docs as a shared writing environment. Group members jointly planned, drafted, revised, and edited their argumentative essays within the shared document. The collaborative process allowed students to exchange ideas, comment on one another's contributions, negotiate alternative viewpoints, and collectively refine the organization and development of their arguments. Rather than receiving individualized automated feedback, students relied primarily on peer interaction and discussion to identify problems and improve their texts. The shared digital environment therefore functioned as a space for collaborative knowledge construction throughout the writing process.

Instructional Procedures

Prior to the instructional intervention, students in both groups completed a pre-test to measure their initial argumentative writing performance. The intervention was subsequently conducted over eight instructional meetings, during which both groups received comparable learning objectives, writing topics, instructional materials, and classroom duration. To ensure instructional consistency, the same teacher facilitated both classes, while the researcher observed the implementation and coordinated the learning activities throughout the study. The only distinction between the two groups was the technology-enhanced instructional approach employed during the writing process.

During the intervention, students were required to produce a series of argumentative essays related to topics aligned with the tenth-grade English curriculum. Each instructional cycle generally consisted of four stages: (1) introduction of the writing topic and discussion of argumentative text structure, (2)

drafting the essay individually or collaboratively depending on the assigned instructional approach, (3) revising the draft based on either AI-assisted or peer-generated feedback, and (4) submitting the revised essay for classroom evaluation. This repeated writing cycle encouraged students to engage continuously in planning, drafting, revising, and reflecting on their writing development throughout the intervention period.

Students assigned to the AI-assisted feedback group completed their writing individually using Grammarly as an automated writing support tool. After drafting each essay, students uploaded their work to Grammarly, reviewed the automated suggestions, and revised language-related problems involving grammar, vocabulary, sentence structure, punctuation, spelling, and writing mechanics before submitting the final version. Rather than functioning as an automatic correction tool, Grammarly was introduced as a learning resource intended to encourage students to evaluate and improve their own writing through immediate feedback.

Students in the collaborative digital writing group worked in small groups of 3-4 students using Google Docs. The groups were formed based on random assignment. During the writing process, students jointly planned, drafted, revised, and edited their argumentative essays in a shared document. Specific roles were assigned to facilitate participation, while peer feedback was guided through teacher instructions. Students discussed alternative ideas and suggested revisions through the shared document and classroom interaction. When disagreements occurred, students were encouraged to discuss and justify their suggestions before reaching a shared decision, with the teacher providing clarification when necessary.

Research Instruments

This study employed both quantitative and qualitative instruments to address the research objectives comprehensively. Quantitative data were obtained through argumentative writing tests administered before and after the instructional intervention. In both the pre-test and post-test, students were required to compose an argumentative essay individually within the allocated classroom time. The writing prompts were designed to reflect topics familiar to senior high school students while requiring participants to formulate claims, provide supporting reasons and evidence, address alternative viewpoints, and present logical conclusions. Comparable levels of task complexity were maintained across the two tests to ensure fair measurement of students' writing development.

Students' argumentative essays were assessed using an analytic scoring rubric adapted with modifications from Brown and Abeywickrama (2019) and aligned with CEFR B1 writing descriptors. The rubric assessed four dimensions of writing: content, organization, vocabulary, and grammar and mechanics. Content focused on the clarity, relevance, and development of ideas and supporting details. Organization assessed the logical sequencing and coherence of ideas, while vocabulary focused on the appropriateness and range of word choice. Grammar and mechanics assessed grammatical accuracy as well as spelling and punctuation. Each dimension was scored on a five-point scale, from 1 (very poor) to 5 (excellent), and the four dimension' scores were combined and converted to a 100-point scale. The rubric was selected to capture both rhetorical and linguistic dimensions of students' argumentative writing and to allow comparisons of overall writing performance and improvement across individual writing aspects.

Prior to data collection, the writing tasks and assessment rubric were reviewed by the classroom English teacher to ensure their suitability for the students' proficiency level and alignment with the learning objectives of the senior high school curriculum. Throughout the scoring process, both raters discussed minor differences in scoring before determining the final score for each essay, thereby enhancing the consistency and credibility of the assessment.

Students' written products were evaluated using an analytic scoring rubric modified from Brown and Abeywickrama (2019), consisting of four dimensions: content, organization, vocabulary, and grammar and mechanics. Each dimension was scored from 1 to 5, producing a maximum raw score of 20, which was subsequently converted to a standardized score on a 100-point scale. To promote scoring consistency, the essays were independently assessed by two raters, and the final score for each student was calculated as the mean of the two raters' scores. Inter-rater reliability was examined using Pearson's correlation, which showed strong agreement between the raters for both the pre-test ($r = .835$, $p < .001$) and post-test ($r = .818$, $p < .001$).

Semi-structured interviews were conducted after the instructional intervention to obtain deeper insights into students' experiences with the two digital writing approaches. Students from each instructional group were purposively selected for interview to represent different learning experiences and achievement levels. The semi-structured interview protocol consisted of 15 questions addressing students' experiences with the instructional approach, their use and interpretation of feedback, revision processes, perceived benefits and difficulties, and perceptions of how the instructional approach

influenced their argumentative writing. Approximately 10 students in total participated in the interviews, with participants selected from both instructional groups. Each interview lasted approximately 7-10 minutes. With participants' consent, the interviews were audio-recorded and subsequently transcribed for thematic analysis.

Data Analysis

Quantitative data were analyzed using descriptive statistics, tests of assumptions, paired-samples t-tests, independent-samples t-tests, and gain-score analysis. Descriptive statistics were used to summarize students' pre-test and post-test writing performance. Normality was assessed using the Shapiro–Wilk test, while homogeneity of variance was examined using Levene's test. Paired-samples t-tests were conducted separately for the Grammarly and Google Docs groups to determine whether students demonstrated significant improvement following the intervention. Gain scores were calculated by subtracting each student's pre-test score from the corresponding post-test score, and an independent-samples t-test was used to compare the mean gain scores between the two groups. Improvement across the four writing dimensions—content, organization, vocabulary, and grammar and mechanics—was examined using descriptive comparisons of pre-test and post-test mean scores. Statistical significance was evaluated at the .05 level.

To complement the significance tests, effect sizes were calculated to determine the magnitude of the observed differences and improvements. Cohen's *d* was used to estimate the magnitude of within-group improvement and between-group differences, with larger absolute values indicating greater practical differences. Reporting effect sizes alongside statistical significance provides a more informative interpretation of the

effectiveness of the two instructional approaches, particularly given the relatively small classroom-based sample.

Qualitative data from the semi-structured interviews were analyzed thematically to identify patterns in students' experiences with Grammarly and Google Docs. The analysis followed a systematic process of data familiarization, initial coding, theme construction, review and refinement of themes, and interpretation. Interview recordings were transcribed before the researcher repeatedly read the transcripts to become familiar with the data and record initial analytical observations. Relevant segments were then coded according to their meanings and grouped into broader categories. The emerging categories were reviewed and refined to ensure that each theme represented a coherent pattern in the participants' responses. Finally, the themes were interpreted in relation to the quantitative findings and the theoretical framework of the study.

Trustworthiness of the qualitative findings was supported through careful transcription of the interview recordings, repeated review of the transcripts, and systematic checking of emerging themes against relevant excerpts from participants' accounts. The researcher reviewed the developing themes to ensure that interpretations remained grounded in the interview data. The qualitative findings were subsequently integrated with the quantitative results to strengthen the explanatory interpretation of the mixed-methods findings.

RESULT AND DISCUSSION

To determine whether AI-assisted feedback and collaborative digital writing differed in supporting students' argumentative writing development, several statistical analyses were performed. Prior to hypothesis testing, the assumptions required for parametric analysis were examined. The Shapiro–Wilk test

indicated that the data were generally normally distributed, while Levene's test confirmed the homogeneity of variances between the two instructional groups ($F = 2.495, p = .123$). These findings supported the use of paired-samples and independent-samples *t*-tests to analyze students' writing performance.

Descriptive statistics for both instructional groups are presented in Table 1.

Table 1 Descriptive Statistics of Students' Writing Performance

Group	n	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain
AI-assisted Feedback	17	46.59 (9.41)	75.53 (7.43)	28.94
Collaborative Digital Writing	20	50.25 (8.32)	70.70 (6.54)	20.45

Table 1 presents the descriptive statistics of students' argumentative writing scores before and after the instructional intervention. Both instructional groups demonstrated higher mean scores on the post-test than on the pre-test, indicating improvements in argumentative writing performance following the implementation of technology-enhanced writing instruction. The AI-assisted feedback group improved from a mean score of 46.59 ($SD = 9.41$) to 75.53 ($SD = 7.43$), yielding an average gain of 28.94 points. Similarly, the collaborative digital writing group increased from 50.25 ($SD = 8.32$) to 70.70 ($SD = 6.54$), with an average gain of 20.45 points. Although both instructional approaches were associated with positive learning gains, the AI-assisted feedback group demonstrated a larger improvement in mean scores. To determine whether these observed differences were statistically significant, inferential statistical analyses were subsequently performed.

The paired-samples *t*-test results are summarized in Table 2.

Table 2. Paired-Samples *t*-Test Results

Group	Mean Difference	<i>t</i>	<i>df</i>	<i>p</i>
AI-assisted Feedback	28.94	-20.447	16	< .001
Collaborative Digital Writing	20.45	-11.217	19	< .001

The paired-samples *t*-test revealed statistically significant improvements in both instructional groups. Students who received AI-assisted feedback demonstrated a mean increase of 28.94 points, with the difference reaching statistical significance, $t(16) = -20.447, p < .001$. Likewise, students in the collaborative digital writing group improved significantly, recording a mean increase of 20.45 points, $t(19) = -11.217, p < .001$. The magnitude of the within-group improvements was also substantial, with very large effect sizes for both the AI-assisted feedback group (Cohen's $d = 4.96$) and the collaborative digital writing group (Cohen's $d = 2.51$). These findings suggest that integrating digital technologies into argumentative writing instruction positively influenced students' writing performance regardless of the instructional approach employed. Nevertheless, the greater mean gain observed in the AI-assisted feedback group indicates that the two approaches may differ in the extent to which they facilitate writing development.

To compare the effectiveness of the two instructional approaches, an independent-samples *t*-test was conducted using students' gain scores. The results are presented in Table 3.

Table 3. Independent Sample *t*-Test Results

Comparison	Mean Difference	<i>t</i>	<i>df</i>	<i>p</i>
AI-assisted Feedback vs. Collaborative Digital Writing	8.49	3.581	35	.001

The independent-samples *t*-test revealed a statistically significant difference between the two instructional approaches, $t(35) = 3.581$, $p = .001$. The between-group difference in gain scores was also large (Cohen's $d = 1.21$), indicating that the difference between the two instructional approaches was not only statistically significant but also practically meaningful. This finding indicates that students who received AI-assisted feedback achieved significantly greater improvements in argumentative writing than those who participated in collaborative digital writing. While both instructional approaches effectively enhanced students' writing performance, AI-assisted feedback appeared to provide stronger support for overall improvement during the intervention period.

The quantitative results showed that both instructional groups demonstrated significant improvement in argumentative writing performance following the intervention. Before the intervention, the Grammarly group obtained a mean pre-test score of 46.59, whereas the Google Docs group obtained a slightly higher mean score of 50.25. After the intervention, the mean score of the Grammarly group increased to 75.53, while the Google Docs group increased to 70.70. Thus, the Grammarly group showed a mean gain of 28.94 points, compared with 20.45 points for the Google Docs group.

Paired-samples *t*-tests indicated that the improvement within each group was statistically significant. For the Grammarly

group, writing performance increased significantly from pre-test to post-test, $t(16) = -20.447$, $p < .001$. The corresponding effect size was very large (Cohen's $d = 4.96$), indicating a substantial within-group improvement. Similarly, the Google Docs group demonstrated a statistically significant improvement, $t(19) = -11.217$, $p < .001$, with a very large within-group effect size (Cohen's $d = 2.51$).

To determine whether the magnitude of improvement differed between the two instructional approaches, an independent-samples *t*-test was conducted on the gain scores. The Grammarly group obtained a significantly higher mean gain score ($M = 28.941$) than the Google Docs group ($M = 20.450$), $t(35) = 3.581$, $p = .001$. The corresponding between-group effect size was large (Cohen's $d = 1.21$), indicating a substantial difference in the magnitude of improvement between the two instructional approaches.

The analysis of individual writing dimensions revealed different patterns across the two groups. In the Grammarly group, grammar and mechanics showed the greatest improvement ($M = 2.2059$), followed by vocabulary ($M = 1.7941$), organization ($M = 1.0294$), and content ($M = 0.7647$). In contrast, the Google Docs group showed the greatest improvement in organization ($M = 1.175$), followed by content ($M = 1.100$), vocabulary ($M = 0.975$), and grammar and mechanics ($M = 0.875$). These results indicate that although the Grammarly group demonstrated greater overall improvement, the two approaches were associated with different patterns of development across writing dimensions.

Qualitative Findings

The qualitative findings provided further insight into how students experienced the two

instructional approaches. Thematic analysis of the interview data identified three main themes: language-focused revision through immediate automated feedback, collaborative idea development through peer interaction, and technical challenges and adaptation during the use of digital writing tools. These themes help explain the different patterns of improvement observed in the quantitative results.

Theme 1: Language-Focused Revision through Immediate Feedback

Students in the AI-assisted feedback group generally described Grammarly as useful for identifying and correcting language-related problems during writing and revision. Interview responses indicated that students noticed grammatical errors, spelling problems, inappropriate word choices, and verb-form errors through the automated feedback. One participant stated, “Grammarly helped me correct grammar mistakes and identify the correct words while writing” (Participant G1). Another participant explained that Grammarly corrected sentences “word by word,” which helped him identify grammatical errors and improve his vocabulary (Participant G2). A third participant reported that Grammarly helped identify misspellings and inappropriate word choices and supported improvement in verb forms (Participant G3). These responses indicate that Grammarly primarily supported students’ attention to linguistic accuracy and encouraged self-review during the writing process.

Theme 2: Collaborative Idea Development and Peer Interaction

Students in the collaborative digital writing group emphasized the contribution of peer interaction to the development and revision of their writing. Participants reported that Google Docs helped them clarify ideas, improve paragraph organization, expand

arguments, and revise their writing through comments from classmates. One participant stated, “When I forgot some English words, my friends gave suggestions through Google Docs, so I could choose better vocabulary” (Participant Gd2). Another participant explained that “the comments from my classmates helped me improve my sentences and organize my ideas before submitting the final draft” (Participant Gd3). Students also reported that collaborative discussions encouraged them to reconsider their arguments and revise their essays more carefully. These findings suggest that Google Docs primarily supported writing through peer interaction, idea exchange, and collaborative revision.

Theme 3: Technical Challenges and Adaptation

Students also reported several challenges during the implementation of the digital writing activities. Some participants experienced difficulties caused by unstable internet connections, which occasionally interrupted Grammarly’s feedback. One participant explained that “when it was really slow or cutting out, Grammarly would not be able to check my writing.” Another participant initially had difficulty using the commenting function in Google Docs, stating that “I did not understand the comment function on Google Docs, but this got easier with practice during meetings.” Some students also perceived the free version of Grammarly as providing less feedback than the premium version. Despite these challenges, participants generally reported that the difficulties did not prevent them from completing the writing activities. Classroom observations further indicated that the challenges decreased over time as students became more familiar with the digital tools and increasingly performed writing and revision activities with less facilitator support.

The interview data provide further insight into this quantitative finding. Students in the AI-assisted feedback group consistently described Grammarly as a practical tool for identifying and correcting language errors during the writing process. One participant explained that he copied his essay into Grammarly, reviewed the automated corrections, and replaced incorrect words before submitting the final version. Another participant reported that Grammarly provided alternative vocabulary and sentence recommendations, enabling him to improve grammatical accuracy while simultaneously learning from the suggested revisions. These responses indicate that students did not merely accept automated corrections but actively engaged with the feedback to refine their writing independently.

The integration of immediate automated feedback into the writing process appears to have encouraged continuous revision rather than delayed correction. Instead of waiting for teacher comments, students were able to identify grammatical errors, revise sentence structures, and improve vocabulary while their ideas were still being developed. This iterative process likely reduced interruptions during writing and promoted greater awareness of language use throughout the drafting process. Such learning behaviors are closely associated with self-regulated learning, in which learners monitor, evaluate, and improve their own performance through continuous reflection and revision. These findings support previous research suggesting that automated writing evaluation systems encourage more frequent revision and foster learner autonomy by providing timely feedback during text production (Barrot, 2023; Gozali et al., 2024; Karatay & Karatay, 2024; Haddadian et al., 2025).

The present findings are broadly consistent with earlier studies reporting positive effects

of AI-assisted writing tools on students' writing performance. However, the current study extends previous research by demonstrating that the advantages of AI-assisted feedback are not limited to improvements in grammatical accuracy. The integration of interview data revealed that students perceived automated feedback as an opportunity to engage in repeated cycles of drafting, revising, and self-monitoring. This observation suggests that the effectiveness of AI-assisted feedback may stem not only from the quality of the feedback itself but also from the active learning behaviors that it encourages. Consequently, the present study contributes additional evidence that AI-supported writing instruction can facilitate both linguistic development and learner autonomy when implemented as part of a structured writing process rather than as a stand-alone correction tool. This interpretation is supported by recent research on automated writing evaluation and AI-supported writing instruction.

Barrot (2023) reported positive effects of automated written corrective feedback on L2 writing accuracy, while Gozali et al. (2024) emphasized the importance of learners' feedback literacy in interpreting and evaluating automated suggestions. Similarly, Karatay and Karatay (2024) found that automated writing evaluation can provide useful support for linguistic aspects of writing, although its pedagogical effectiveness varies according to how learners engage with the feedback. More recent evidence from Haddadian et al. (2025) further indicates that automated writing evaluation can support revision in argumentative writing by providing timely feedback, while also highlighting the need to consider the limitations of automated systems in addressing higher-order aspects of writing. These findings provide converging evidence for the present result that AI-assisted feedback

can be particularly valuable for language-focused revision while not necessarily replacing the cognitive and social processes involved in developing ideas and arguments.

However, the present findings should also be interpreted alongside evidence showing that the benefits of automated writing feedback are not uniform across learners or writing dimensions. Automated feedback may be particularly useful for identifying language-level problems, but its effectiveness depends on learners' ability to understand, evaluate, and appropriately apply the suggestions provided. In argumentative writing, improvements in grammatical accuracy do not necessarily correspond to equivalent improvements in the development and organization of ideas. The present findings support this distinction: the AI-assisted feedback group achieved the greater overall gain and showed its strongest improvement in grammar and mechanics, whereas the collaborative digital writing group demonstrated comparatively stronger gains in content and organization. This contrast suggests that the higher overall gain associated with AI-assisted feedback should not be interpreted as evidence that automated feedback is superior across all dimensions of argumentative writing.

Although the collaborative digital writing group demonstrated comparatively smaller learning gains, the quantitative results also confirmed significant improvement following the instructional intervention. The interview findings suggest that this improvement was facilitated through collaborative interaction rather than individualized corrective feedback. Several participants explained that they revised their essays after receiving comments from classmates, who helped identify vocabulary choices, grammatical errors, and organizational problems. One student noted that peer feedback encouraged

her to reorganize connections between paragraphs, while another explained that discussing ideas with classmates helped resolve difficulties in selecting appropriate English vocabulary.

This finding provides a useful qualification to the quantitative comparison. Although the collaborative digital writing group did not achieve the same magnitude of overall improvement as the AI-assisted feedback group, its qualitative experiences indicate that peer interaction supported aspects of writing that are less readily addressed through automated language correction. Students had opportunities to explain their ideas, respond to alternative perspectives, and reconsider how their arguments were organized. Thus, the smaller overall gain should not be interpreted as evidence of limited pedagogical value. Rather, it suggests that collaborative digital writing may contribute to dimensions of argumentative writing that are more strongly dependent on interaction, discussion, and shared evaluation.

These responses suggest that collaborative digital writing supported argumentative writing development through social interaction and shared knowledge construction. Rather than focusing primarily on immediate linguistic correction, collaborative writing encouraged students to negotiate meaning, exchange perspectives, and refine arguments collectively before producing the final draft. This learning process can be interpreted through Sociocultural Theory, which emphasizes that learning is mediated through meaningful interaction with others and through the use of cultural and technological tools (Vygotsky, 1978). Similar findings have been reported by Kessler et al. (2012), who highlighted the contribution of collaborative technologies to learner interaction, and by Ebadijalal and Moradkhani (2023), who found that

collaborative digital writing promoted learner engagement, idea development, and higher-order thinking throughout the writing process.

Beyond demonstrating differences in learning outcomes, the present findings highlight an important pedagogical distinction between technology-assisted and technology-mediated writing instruction. Although both instructional approaches integrated digital technologies into classroom practice, they facilitated learning through fundamentally different mechanisms. AI-assisted feedback primarily functioned as an individualized learning support system by providing immediate corrective feedback that enabled students to revise their writing independently. In contrast, collaborative digital writing positioned technology as a shared learning space where knowledge was constructed collectively through discussion, negotiation, and peer interaction. These contrasting mechanisms suggest that the effectiveness of educational technology depends not merely on the digital platform itself but on the pedagogical processes that the technology facilitates.

This distinction contributes to the growing discussion surrounding Technology-Enhanced Language Learning (TELL), which increasingly emphasizes that meaningful technology integration should extend beyond simply adopting digital tools in the classroom. Instead, technology should be viewed as a pedagogical medium capable of supporting different dimensions of language learning depending on how it is implemented. In the context of argumentative writing, AI-assisted feedback appears particularly effective for strengthening linguistic accuracy and promoting learner autonomy, whereas collaborative digital writing provides richer opportunities for developing critical thinking, collaborative problem-solving, and argumentative reasoning. Consequently,

rather than asking which technology is universally more effective, teachers may benefit more from considering which instructional approach best aligns with specific learning objectives and classroom needs.

Similarly, the collaborative digital writing findings extend previous research by illustrating that peer interaction contributes to more than collaborative text production. The interview data indicate that collaborative discussion enabled students to exchange perspectives, justify arguments, and negotiate alternative ideas before producing the final version of their essays. Such collaborative dialogue appears particularly valuable in argumentative writing, where constructing persuasive claims requires learners to evaluate evidence, anticipate counterarguments, and consider multiple viewpoints. These observations reinforce the argument that collaborative digital writing supports not only language learning but also broader cognitive processes associated with argumentative reasoning.

An important implication emerging from the present findings is that comparing digital technologies solely on the basis of statistical improvement may oversimplify the complexity of writing instruction. Each technology embodies different pedagogical affordances that shape how students engage with the writing process. AI-assisted feedback primarily supports individual revision through immediate language-focused feedback, whereas collaborative digital writing creates opportunities for shared reflection, discussion, and collective knowledge construction. Recognizing these complementary functions allows educators to move beyond the question of which technology is "better" and instead consider how different technologies can be combined to address multiple dimensions of

writing development within a single instructional sequence.

Taken together, the quantitative and qualitative findings demonstrate that AI-assisted feedback and collaborative digital writing represent two complementary pedagogical approaches rather than competing instructional technologies. Although students receiving AI-assisted feedback achieved significantly greater gains in argumentative writing performance, the interview data revealed that each instructional approach supported different aspects of the writing process. AI-assisted feedback primarily facilitated linguistic accuracy and independent revision through immediate automated feedback, whereas collaborative digital writing promoted idea development, peer interaction, and collaborative knowledge construction. These complementary strengths suggest that technology integration in EFL writing instruction should be guided by pedagogical objectives instead of technological preference alone.

From a practical perspective, the findings provide several implications for English language teachers. When the instructional objective is to improve grammatical accuracy, vocabulary use, and independent revision, AI-assisted feedback may serve as an effective instructional support because it enables learners to receive immediate corrective feedback throughout the writing process. Conversely, if the primary objective is to strengthen students' critical thinking, collaborative problem-solving, and argumentative reasoning, collaborative digital writing offers meaningful opportunities for peer interaction and shared text construction. Rather than replacing one approach with another, teachers may achieve greater instructional benefits by integrating both approaches strategically according to specific learning outcomes and classroom contexts.

The findings also suggest that integrating both instructional approaches within a single writing cycle may provide greater pedagogical benefits than relying exclusively on one approach. For example, students may initially develop ideas collaboratively through Google Docs by exchanging opinions, organizing arguments, and negotiating evidence with peers. Once a complete draft has been produced, AI-assisted feedback can subsequently be used to refine grammatical accuracy, sentence structure, vocabulary, and writing mechanics before final submission. Such an integrated instructional sequence allows students to benefit from both collaborative knowledge construction and individualized language revision, thereby addressing multiple dimensions of argumentative writing simultaneously. Future classroom implementation may therefore focus less on selecting a single digital platform and more on designing complementary learning experiences that maximize the strengths of different technologies.

CONCLUSION

This study compared the effectiveness of AI-assisted feedback and collaborative digital writing in supporting Indonesian EFL students' argumentative writing development. The findings demonstrated that both instructional approaches significantly improved students' writing performance. However, students who received AI-assisted feedback achieved greater learning gains than those who participated in collaborative digital writing. The integration of quantitative and qualitative findings further indicated that the two instructional approaches facilitated writing development through different pedagogical mechanisms. While AI-assisted feedback promoted immediate language revision and greater learner autonomy, collaborative digital writing encouraged idea

development, peer interaction, and collaborative knowledge construction.

These findings suggest that technology integration in EFL writing instruction should be guided by instructional objectives rather than by technological preference alone. AI-assisted feedback may be particularly beneficial for supporting linguistic accuracy and independent revision, whereas collaborative digital writing offers meaningful opportunities for collaborative learning and argumentative development. Overall, both instructional approaches represent valuable pedagogical resources that can be integrated strategically to support different aspects of students' argumentative writing development.

This study contributes comparative evidence by demonstrating that the pedagogical value of digital writing technologies depends on the dimensions of writing development they are designed to support. Rather than identifying one technology as universally superior, the findings show that AI-assisted feedback and collaborative digital writing offer complementary affordances that can be aligned with different instructional objectives.

Several limitations should be acknowledged. The study involved 37 students from two intact Grade 10 classes in a single secondary-school context, which limits the generalizability of the findings to other EFL populations and educational settings. The intervention also focused specifically on argumentative writing and was conducted within a limited instructional period. Future research could therefore examine larger and more diverse samples, longer intervention periods, and other writing genres. Further studies could also investigate the integration of AI-assisted feedback and collaborative digital writing within the same instructional sequence to determine whether their

complementary affordances can produce additional benefits for EFL learners.

REFERENCES

- Barrot, J. S. (2023). Using automated written corrective feedback in the writing classroom: Effects on L2 writing accuracy. *Computer Assisted Language Learning*, 36(4), 584–607. <https://doi.org/10.1080/09588221.2021.1936071>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Brown, H. D., & Abeywickrama, P. (2019). *Language assessment: Principles and classroom practices* (3rd ed.). Pearson.
- Creswell, J. W., & Guetterman, T. C. (2023). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed.). Pearson.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.
- Ebadijalal, M., & Moradkhani, S. (2023). Impacts of computer-assisted collaborative writing, collaborative prewriting, and individual writing on EFL learners' performance and motivation. *Computer Assisted Language Learning*, 38(1–2), 291–315. <https://doi.org/10.1080/09588221.2023.2178463>
- Golonka, E. M., Bowles, A. R., Frank, V. M., Richardson, D. L., & Freynik, S. (2014). Technologies for foreign language learning: A review of technology types and their effectiveness. *Computer Assisted Language Learning*, 27(1), 70–105. <https://doi.org/10.1080/09588221.2012.700315>
- Gozali, I., Wijaya, A. R. T., Lie, A., Cahyono, B. Y., & Suryati, N. (2024). Leveraging the potential of ChatGPT as an automated

- writing evaluation tool: Students' feedback literacy development and AWE tools integration framework. *The JALT CALL Journal*, 20(1), 1–22. <https://doi.org/10.29140/jaltcall.v20n1.1200>
- Graham, S., MacArthur, C. A., & Fitzgerald, J. (Eds.). (2021). *Best practices in writing instruction* (3rd ed.). Guilford Press.
- Haddadian, G., Kim, M. K., & Haddadian, N. (2025). A Systematic Review of Automated Writing Evaluation Tools in Argumentative Writing for English as Foreign Language Education. *Research Synthesis in Applied Linguistics*, 1–51. <https://doi.org/10.1080/29984475.2025.2598266>
- Hanafiah, W., Aswad, M., Sahib, H., & Yassi, A. H. (2022). The impact of TELL on vocabulary learning, speaking skill, and foreign language speaking anxiety: The case study of Indonesian EFL learners. *Education Research International*, 2022. <https://doi.org/10.1155/2022/5500077>
- Hyland, K. (2003). *Second language writing*. Cambridge University Press.
- Iberahim, A., Yunus, M. M., & Sulaiman, N. A. (2023). A review on technology-enhanced language learning (TELL). *International Journal of Academic Research in Business and Social Sciences*, 13(2), 1509–1519. <https://doi.org/10.6007/IJARBS/v13-i2/16496>
- Karatay, Y., & Karatay, L. (2024). Automated writing evaluation use in second language classrooms: A research synthesis. *System*, 123, 103332. <https://doi.org/10.1016/j.system.2024.103332>
- Kessler, G., Bikowski, D., & Boggs, J. (2012). Collaborative writing among second language learners in academic web-based projects. *Language Learning & Technology*, 16(1), 91–109.
- Khatami, M. R., & Suryati, N. (2026). Automated writing evaluation and generative AI in Indonesian EFL writing: A systematic review of effects, engagement, and pedagogical implications. *JEELS (Journal of English Education and Linguistics Studies)*, 13(2), 633–660. <https://doi.org/10.30762/jeels.v13i2.7694>
- Kormos, J. (2023). The role of cognitive factors in second language writing and writing to learn a second language. *Studies in Second Language Acquisition*, 45(3), 622–646. <https://doi.org/10.1017/S0272263122000481>
- Luo, Y., Xia, Y., & Lu, X. (2025). A systematic review of the role of artificial intelligence in second language writing education. *Digital Studies in Language and Literature*. <https://doi.org/10.1515/dsll-2025-0001>
- Myles, J. (2002). Second language writing and research: The writing process and error analysis in student texts. *TESL-EJ*, 6(2). <http://tesl-ej.org/ej22/a1.html>
- Nguyen, D. M. Q. (2026). The role of ChatGPT in providing written corrective feedback for EFL academic writing: A literature review. *International Journal of AI in Language Education*, 3(1), 35–47. <https://doi.org/10.54855/ijaile.26313>
- O'Neill, R., & Russell, A. M. T. (2019). Stop! Grammar time: University students' perceptions of the automated feedback program Grammarly. *Australasian Journal of Educational Technology*, 35(1), 42–56. <https://doi.org/10.14742/ajet.3795>
- Pan, Y., Yu, P., Yin, X., Yang, H., Long, X., & Tong, Q. (2026). The promise and limits of artificial intelligence in writing assessment and instruction: A systematic review. *Educational Technology Research and Development*. <https://doi.org/10.1007/s11423-026-10659-2>
- Sanz-Tejeda, A., Domínguez-Oller, J. C., Baldaquí-Escandell, J. M., Gómez-Díaz, R., & García-Rodríguez, A. (2026). The impact of generative AI on academic

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- reading and writing: A synthesis of recent evidence (2023–2025). *Frontiers in Education*, 10, 1711718. <https://doi.org/10.3389/feduc.2025.1711718>
- Tang, W., Wang, Z., & Yan, G. (2026). What are we missing in AI-supported L2 writing research? A systematic review from 2014 to 2024. *Journal of Computer Assisted Learning*. <https://doi.org/10.1002/jcal.70262>
- Teng, M. F., & Yue, M. (2023). Metacognitive writing strategies, critical thinking skills, and academic writing performance: A structural equation modeling approach. *Metacognition and Learning*. <https://doi.org/10.1007/s11409-022-09328-5>
- Veddayana, C., Suyitno, I., Widyartono, D., & Aldresti, F. (2025). Systematic review: How technology supports collaborative writing learning in higher education. *Electronic Journal of e-Learning*, 23, 64–78. <https://doi.org/10.34190/ejel.23.3.3974>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press.
- Zhang, J., Zhang, L. J., & Wang, X. (2026). The use of ChatGPT as a writing feedback tool in second language learning and teaching: A systematic review. *Educational Studies*. <https://doi.org/10.1080/03055698.2026.2698519>