

AI-enhanced peer collaboration in the digital writing classroom: A case from Indonesia

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ABSTRACT

Despite growing interest in peer collaboration and AI-assisted language learning, existing studies often examine these approaches in separate ways. This study responds to this gap by investigating the effectiveness of AI integration into peer collaborative practices in influencing students' writing and their experiences in authentic digital writing classrooms. Students' writing performance was examined after AI-enhanced peer collaboration, along with their experiences during the implementation of the digital writing classroom. Comparisons between utilisation in pair-structured writing collaboration and unstructured AI-enhanced peer collaboration practices were also measured. A mixed-methods study was employed, involving 30 undergraduate EFL students who participated in AI-structured peer collaboration throughout one semester, while another 30 students were assigned to unstructured strategy implementation. The quantitative data collected were analysed using the SPSS parametric test, and the qualitative data were analysed using thematic analysis. The results of the independent t-test and effect size tests revealed that students' writing performance has notably improved ($p < .005$, $d = 2.27$; large effect size). Students also expressed positive perspectives on AI-enhanced peer collaboration, indicating support from SEL, interactional process, and ecological perspectives. This study highlights the pedagogical value of integrating AI into EFL writing instruction to enhance students' writing performance and collaborative skills.

Keywords: AI; igital learning; peer collaboration; writing

INTRODUCTION

Writing for students learning English as a foreign language (EFL) is a multifaceted, intricate cognitive and metacognitive effort that goes well beyond simply learning grammar rules (Sun et al., 2024). When students seek to express complex concepts, they simultaneously engage in language translation, vocabulary retrieval, and new rhetorical patterns (Călinescu, 2024). They also encounter writing anxiety and a propensity to over-rely on safe and formulaic language rather than engaging in deep critical expression, which are common outcomes of this high cognitive load (Hyland & Hyland, 2019). Additionally, they often find it difficult to align the specific structural requirements of standardised academic discourse with their own cultural rhetorical patterns because writing practices are culturally situated (Leila, 2022). In addition to a significant shift in writing in a conventional way, writing media rapidly move from paper and pencil to digital platforms, and they are required to deal with not only these fundamental linguistic but also dynamic, collaborative, and multimodal affordances of digital writing environments.

In response to this, the digital writing classroom has become a centre of pedagogical innovation in recent EFL classroom settings because the platforms offer interactive, process-oriented, and highly personalised practice to students (Geng et al., 2022; Zhang & Yu, 2023; Zhang et al., 2022). The integration of digital technologies into teaching, practicing, and evaluating writing has transformed into a more interactive and learner-centred design of learning (Kerimbayev et al., 2023). However, the critical questions have raised some issues regarding interaction quality, learner engagement, and instructional design in classroom practices (Sun et al., 2024; Cahyono et al., 2024). According to Chen and Yeh (2025), many EFL students find it difficult to convert digital involvement into noticeable improvements in their writing skills, even though the role of technology is deliberately to support collaborative learning. For instance, EFL students experience limited peer contact (Kos, 2023), a lack of scaffolding in digital settings (Ahmed Abdel-Al Ibrahim et al., 2023), and a lack of personalised and adaptive feedback methods that cater to students' needs (Ratnawati et al., 2026). Furthermore, students increase their cognitive load due to unstrategic digital tools utilization (Bahari et al., 2023). Therefore, investigating teachers' scaffolding integrated into the digital platform application is a call for the present study that supports collaborative writing and learner autonomy.

Concurrently, AI is intensively being utilised in digital writing classrooms as a strategy to address well-established issues in EFL writing learning to promote students' learning autonomy (Emerson, 2024; Werdiningsih et al., 2024), feedback provision (Wiboolyasarin et al., 2025), and instructional efficiency (Kolajo, 2025). Regarding the previous research findings from Gahane et al. (2025) and Kindenberg (2024), AI-powered tools are generally developed as a technology-oriented and individually-oriented approach in the field of study. These tools are used as personal writing assistants, automated evaluators of students' work, and instantaneous language feedback, as well as models of academic discourse (Liang, 2025). However, little critical analysis of AI in educational consequences for social interaction and emotional engagement in writing processes (Guo & Wang, 2025). The existing

studies ignore the social and emotive aspects of EFL writing and restrict writing development to accuracy-oriented results (Liu et al., 2022). According to Järvelä et al. (2023), AI tools' effectiveness in promoting peer collaboration and emotional regulation in digital settings has also been called for further investigation. This means that AI's roles are not merely about being a personal assistant but also about being a peer mediator to promote students' collaborative writing (Zhang & Rau, 2023), socio-emotional learning (Maples et al., 2025), and digital learning (Hidayat-ur-Rehman, 2024).

The practices of socio-emotional learning (SEL) are expected to boost students' social awareness and 21st-century skills, particularly communication and collaboration. Peer collaboration, one of the activities for the implementation of SEL, has long been recognised as a crucial pedagogical strategy in writing contexts (Chen & Lee, 2022). Peer collaborative writing is grounded in sociocultural theory (Vygotsky, 1978). It supports students' language development and higher-order thinking by accommodating students in co-constructing meaning through discussion, peer learning, and group problem-solving (Chen et al., 2022; Yeh & Sharma, 2024). In practices, students are promoted to engage with a variety of viewpoints, vocabulary, and writing insights across their own writing process as well as peer-mediated activities (Li & Hebert, 2024). Palenkahu et al. (2024) mention that this activity also helps students elaborate and defend their writing decisions, which promotes metacognitive regulation learning. However, the effectiveness of peer collaboration is influenced by contact quality and relevant scaffolding provision (Homayouni, 2022). Therefore, the planned direction is notably requested to allow students' peer engagement, which leads to critical feedback and meaningful and constructive cooperation.

Furthermore, in EFL writing contexts, peer collaboration has been widely recognised as a strategy to foster learner autonomy, critical thinking, and language development (Chen & Liu, 2025). Previous studies (An et al., 2025; Rahimi, 2024) report that this activity is tendentiously advantageous for students in developing their writing, yet existing studies have underexamined the quality of interactions and students' engagement during the writing process. According to Teng and Zhang (2020), two constructs of peer collaboration, namely feedback handling and peer learning, are substantial but limited in sufficient scaffolding. In addition, the previous research from Xiong (2025) explores the socio-emotional elements and their contributing factors on a large scale that affect students' participation in driving to the writing performance. To do so, the current study delves into integrating the interplay of constructs of AI tools, teachers' scaffolding, collaboration in digital learning environments, and students' writing processes through socio-emotional learning, their interaction process, and ecological aspects of learning, driving students' writing performance. In conducting this research, technological affordances, pedagogical circumstances, and affective aspects are interconnected to foster students' writing competence.

The interactional process, a main action of peer collaboration, has long been acknowledged as a machine which proceed students to co-construct knowledge,

negotiate meaning, and develop higher-order thinking skills in writing contexts. It also refers to the social interaction that serves as a mediator for learning, allowing students to externalise their ideas, get feedback, and improve their language and cognitive abilities (Storch, 2019). Through interactions, students are enabled to improve writing quality and learner autonomy by fostering idea sharing, mutual scaffolding, and critical reflection (Zhang & Hyland, 2018). Currently, peer engagement is in student-student-AI ecosystems, changing from simple learner-to-learner interactions to more complicated interconnectedness among variables. AI tools serve as a cognitive partner by offering prompt feedback, producing writing recommendations, and encouraging thoughtful conversations among peers (Barnes et al., 2024). In addition, the quality of processes through which students interpret, assess, negotiate, and incorporate AI-generated input into their collaborative writing practices.

In AI-enhanced language learning, incorporating socio-emotional learning (SEL) into writing peer collaboration is beneficial to produce high quality writings. According to Sethi and Jain (2024), SEL are fundamentally emphasised of empathy, social negotiation, and emotional scaffolding, while AI-mediated tools effectively expedite lower-order linguistic adjustments. Moreover, systematic SEL gives students the emotional control and interpersonal skills necessary to resolve conflicting AI recommendations, handle peer criticism, and preserve collective agency. In classroom practices, EFL students often encounter particular cognitive and affective conflicts when navigating digital contexts where peer-review loops and automated algorithmic feedback converge. This condition frequently increases digital anxiety or interpersonal vulnerability (de Laat et al., 2020). To do so, teachers should ensure that technology enhances socio-cognitive development by integrating SEL into AI-augmented collaborative frameworks (Salem, 2026).

Viewing from ecological space, AI-enhanced peer collaboration combines the micro and mesosystem viewpoints in EFL writing contexts where students negotiate meaning, share feedback, and co-construct knowledge through interactional processes that influence social participation and language development (Daly et al., 2022). The incorporation of AI, an ecological agent that mediates students' engagement with tasks, peers, and learning resources, changes the nature of interactions (Chen et al., 2022). SEL contributes as a tool for empowering students to control their emotions, exhibit empathy, form wholesome connections, and make responsible judgments (OECD, 2021). Therefore, it is necessary to investigate the interactional processes through which students negotiate with AI-generated feedback, manage interpersonal relationships, and exercise social-emotional competencies. Ecological analysis of interrelated dimensions provides a comprehensive understanding of social, technological, and pedagogical affordances in attaining language learning outcomes.

In EFL writing contexts, the application of AI has emerged its popularity due to pedagogical needs (Alharbi, 2023; Seyri & Ghiasvand, 2025; Xiao et al., 2025). AI technologies offer more effective involvement with drafting and revision processes by giving students personalised support and timely feedback (Guo et al., 2025).

Furthermore, AI also assists in facilitating students' diverse proficiency levels by providing scalable and data-informed support that meets their individual writing needs (Salnedab et al., 2026). However, research (Chu & Liu, 2025; Hidayat et al., 2025) still view AI utilisation as an individual-oriented activity, such as writing accuracy assistance, idea generation, and personalised feedback. Therefore, AI-mediated peer collaboration is still underexplored in terms of the maintenance of collaborative processes with teachers' guided design. Furthermore, little study focuses on interaction quality, emotional control, and interactional process which emerge the dynamic interplay between students, peers, instructional design, and technology mediation. To fill these gaps, the present study takes a holistic stance, manifesting AI as a tool for mediation in structured peer cooperation, which is concerned with the following questions:

1. How does AI-enhanced peer collaboration impact students' writing performance?
2. How do students perceive the implementation of AI-enhanced peer collaboration in a digital writing classroom?

The answers to the above research questions offer new insights into the operational dynamics of computer-assisted language learning (CALL) paradigms, with a particular emphasis on the insufficiently researched intersection of peer cooperation and AI-mediated tools. The current study focuses on classifying and analysing particular kinds of interactional variables and the correlational impact of generative artificial intelligence on EFL writing proficiency. One of our main contributions is a thorough analysis of distributed scaffolding in digital environments, which provides fresh perspectives on how students maximise the ecological balance between collaborative human-to-human meaning negotiation and automated algorithmic feedback. Writing programs that emphasise digital literacy, peer-review proficiency, and mixed research communication are implied by the significance. By shedding light on how EFL students create and communicate meaning in digitally mediated academic interactions and shifting composition spaces from speculative technology integration to sustainable and interactive knowledge expansion in English Language Teaching (ELT).

METHODS

Research Design

This study used a convergent parallel mixed-methods research design to delve into the effects of AI-enhanced peer collaboration on EFL students' writing ability and their perceptions of its application in a digital writing classroom. In the quantitative phase, the study employed a quasi-experimental design through students' engagement in a pre-test–post-test design over the course of a semester, with both groups using AI assistance in completing their tests. The qualitative phase used semi-structured interviews to investigate students' perceptions during the implementation of AI-enhanced peer collaboration in classroom writing.

Several sequential processes were involved in conducting the mixed methods study. These activities included: (1) developing research instruments for both the qualitative and quantitative phases, (2) conducting research instrument validation and data collection, (3) collecting the data, compiling information from both qualitative and quantitative sources within the concurrent timeframe, and (4) combining the quantitative and qualitative findings to offer a deeper and more nuanced understanding of the study issue.

Research Site

The research was carried out at Indonesian private universities. The two universities were chosen as the research locations because they cater to a wide range of students from different intellectual, cultural, and socioeconomic backgrounds. This provides a rich environment for researching technology-enhanced learning strategies. Furthermore, in response to the needs of the digital age, students progressively incorporated digital technology and artificial intelligence (AI) tools into teaching and learning processes to improve students' academic performance and employability. This context provides a relevant setting for examining how SEL competencies and interactional processes emerge and develop during AI-enhanced peer collaboration in EFL writing.

Research Participants

The research participants were 60 undergraduate EFL students who were assigned to the control (30 students) and intervention groups (30 students). Purposive sampling was used to divide the students into control and intervention groups. Participants were chosen based on particular traits related to the objective of the study, guaranteeing a diverse cohort with various learning styles and interventions.

The use of a quasi-experimental design, which permitted the comparison of the intervention's effects without random assignment, is indicated in the demographic information in [Table 1](#). The qualitative phase dealt with twelve selected students, as indicated in [Table 2](#).

Table 1. Demographic Information of Research Participants

Category	Classification	N	%
Gender	Male	14	23
	Female	46	77
Age	18-20	24	40
	21-23	36	60
	24-26	0	0
Years of Learning English	5-10	18	30
	10-15	33	55
	15-20	9	15
Effort of AI utilisation in English Writing	Yes	56	94
	No	4	6
Background knowledge of Collaborative Writing	Yes	53	89
	No	7	11

Experience of AI utilisation in collaborative Writing	Yes	60	100
	No	0	0

Table 2. Interview Participants

Students' code	Gender	Age	Score Rank	Category of Writing Performance
S1	Female	21	60-69	Low
S2	Male	19	70-79	Intermediate
S3	Female	20	80-above	High
S4	Female	20	70-79	Intermediate
S5	Male	21	60-69	Low
S6	Female	20	80-above	High
S7	Female	20	60-69	Low
S8	Female	21	60-69	Low
S9	Male	20	70-79	Intermediate
S10	Male	19	80-above	High
S11	Female	19	80-above	High
S12	Female	20	70-79	Intermediate

Research Instrument

The present study used pre-test and post-test writing tests for quantitative data and semi-structured interviews for qualitative data. The tests were adapted from the IELTS Writing Test 2 (British Council, 2023), and semi-structured interview protocols were adapted from Teng and Zhang (2020) and Wu et al. (2024). Both pre-test and post-test have similar task types (argumentative essay), time duration of completion (100-120 minutes), text combination (text and visual), and students' grouping for collaborative writing (pair work).

Before test administration, the Cohen's Kappa test was conducted, and the values ranged from 0.65 to 0.79, which indicated a moderate level of agreement between the raters. According to McHugh (2012), for research purposes, a Kappa score in this range is deemed appropriate since it acknowledges slight inconsistencies while demonstrating a sufficient level of inter-rater reliability. Students' written texts were evaluated using scoring rubrics by Jacobs et al. (1981), including content development, organisation, language use, and mechanics.

Regarding the qualitative instrument, the semi-structured interview comprised students' experiences in the implementation of structured AI-enhanced peer collaboration in terms of social-emotional learning perspectives, interactional perspectives, and ecological perspectives.

Data Collection

In quantitative data collection, students wrote digital writing for the pre-test and post-test in response to a writing prompt to measure EFL students' writing

performance. The pre-test was distributed in the first meeting, and the post-test was administered after a semester of pedagogical mediation (Table 3) was completed.

In qualitative data collection with twelve students with purposively selected (low, intermediate, and advanced writing scores from intervention groups), the interview session was conducted synchronously via Zoom virtual meeting, with 40-45 minutes per student in Indonesian to dig into their perceptions without language barriers.

Table 3. Pedagogical Mediation

No	Procedures of the writing class	AI-Structured Peer Collaboration	AI-Unstructured Peer Collaboration
1	Orientation	Explicit instructions on guided AI use within peer groups	General introduction to AI tool use in peer collaboration
2	Pre-Test	Peer writing pre-test administered with AI assistance.	Peer writing pre-test administered with AI assistance.
3	Planning	Structured and guided group planning to support joint meaning-making.	Group planning conducted freely
4	Drafting	Peer drafting with step-by-step scaffolding	Collaborative drafting with independent rules in pairs
5	AI Interaction	Instructional rules on AI prompts and output before adoption for students' writing.	Students' autonomy to drive AI use without regulation.
6	Peer Feedback	Instructional protocols of feedback and rubrics for feedback handling and peer learning	Informal and unsystematic criteria of feedback rubrics
7	Revision	Classroom facilitation (synchronous and asynchronous) on revision activity and AI-supported checklists to foster collaborative decision-making.	Handling students' feedback and academic integrity are the main roles of this activity.
8	Reflection	Collaborative process reflection with guided rubrics to drive students' autonomy	Individual and general open-ended reflection
9	Post-Test	Peer writing post-test administered with AI assistance.	Peer writing post-test administered with AI assistance.

Data Analysis

The research data were analysed from students' written essays and interview recordings to drive on answering research questions. Concerning the students' scores on writing, an independent t-test was used to look at the difference between the intervention and control groups. Before conducting this test, several statistical tests were conducted as indicated in [Table 4](#).

Table 4. A series of statistical tests to independent t-test

No	Statistical Test	Group	Measurement	p-value	Criterion	Interpretation
1	Kolmogorov–Smirnov	Control	Pre-test	0.134	$p > .05$	Normally distributed
2	Kolmogorov–Smirnov	Control	Post-test	0.200	$p > .05$	Normally distributed
3	Kolmogorov–Smirnov	Intervention	Pre-test	0.112	$p > .05$	Normally distributed
4	Kolmogorov–Smirnov	Intervention	Post-test	0.180	$p > .05$	Normally distributed
5	Levene's Test	Control	Pre-test	0.370	$p > .05$	Homogeneous
6	Levene's Test	Intervention	Pre-test	0.650	$p > .05$	Homogeneous
7	Levene's Test	Control	Post-test	0.650	$p > .05$	Homogeneous
8	Levene's Test	Intervention	Post-test	0.420	$p > .05$	Homogeneous

[Table 4](#) pointed out that the normality and homogeneity assumptions were investigated before the parametric analysis was carried out. The pre-test and post-test scores in the control and intervention groups were shown to be normally distributed by the Kolmogorov-Smirnov test, with all significant values more than .05. Additionally, with p-values ranging from .370 to .650, Levene's test showed homogeneous variances across groups for both pre-test and post-test scores. The independent t-test was therefore justified to investigate variations in students' writing performance.

Thematic analysis of qualitative data was performed using [Braun and Clarke's \(2021\)](#) six-phase steps to thematic analysis from semi-structured interviews. First, all interview recordings were transcribed verbatim by Google Docs voice typing text, and we read the written transcripts several times to become familiar with the data. In the coding, researchers identified initial codes that have relevant segments related to the research questions. Third, we grouped similar codes into potential themes based on recurring patterns across students' responses. The emerged themes were SEL (Socio-emotional learning), IP (Interactional Process), and EP (Ecological Perspectives), signified by students' interview scripts for each theme. Fourth, we compared the coded data and complete transcripts to ensure the trustworthiness of students' perceptions from interview data. Fifth, we refined the theme by giving relevant names (experiences, challenges, and strategy mechanisms) to the SEL, IP, and EP themes. Finally, the themes were illustrated with representative quotations from students to support the findings.

RESULTS

The impact of AI-enhanced peer collaboration on students' writing performance

The results show that AI-enhanced peer collaboration is impressively effective on students' writing performance. The statistical results showed a significant difference between the intervention group and the control group in post-test writing scores ($p < .005$, $d=2.27$, indicating a large effect on writing performance) as indicated in Table 5.

Table 5. Statistical test of the independent t-test

Variable	N	M	SD	Mean Difference	T	df	P	Cohen's d (d)
Pre-test	30	72.83	5.58					
Post-test	30	85.17	5.27	12.34	9.30	29	< .001	2.27

As presented in Table 5, students' writing performance significantly improved after EFL students were engaged in AI-enhanced peer collaboration activities. With a mean difference of 12.34 points, the average writing score rose from 72.83 (SD=5.58) in the pre-test to 85.17 (SD=5.27) in the post-test. This improvement was found to be statistically significant by the independent t-test ($t=9.30$, $p<.001$). These findings offer proof that AI-enhanced peer cooperation beneficially aids in the improvement of EFL students' writing abilities.

Students' writing performance demonstrated a substantial improvement following the implementation of AI-enhanced peer collaboration. In addition to achieving statistical significance, the intervention produced a large effect size ($d=2.27$), indicating a considerable practical impact on writing achievement. The magnitude of this effect suggests that the intervention was associated with meaningful improvements in students' writing performance over the course of the study. These findings indicate that integrating AI within structured peer collaboration effectively supported iterative feedback, collaborative revision, and reflective writing practices, thereby facilitating greater learning gains. The observed effect size further reflects the instructional value of AI-enhanced peer collaboration, suggesting that this pedagogical approach contributed substantially to students' writing development rather than yielding only modest improvements. Overall, the findings indicate the potential of AI-supported collaborative learning as an effective instructional strategy for enhancing the writing performance of EFL students.

Students' perceptions on the implementation of AI-enhanced peer collaboration in the digital writing classroom

Based on the interview data, participants perceived that socio-emotional learning (SEL), interactional processes, and ecological perspectives were influencing factors of AI-enhanced structured peer collaboration in digital writing environments. The qualitative findings consistently captured that AI is a mediating resource that assists communication, collaboration, feedback exchange, and students' engagement with the learning environment.

Socio-Emotional Learning (SEL)

The collected data revealed that AI integrated into peer interaction increased communication, peer relationships, conflict resolution, and help-seeking behaviour during collaborative writing activities. Regarding communication, students are described as utilising AI to generate ideas, clarify wording, and prepare feedback before interacting with peers. As students prepare for this activity, the process enables them to articulate their ideas and feedback with greater precision and confidence, thereby fostering more meaningful and reciprocal peer interactions. The interview data further indicated that AI served as a collaborative scaffold by providing constructive feedback during the writing process. The role of AI as a complementary resource for collaborative learning. Students are enabled to validate AI-generated suggestions, justify their revisions, and seek clarification through dialogue with their peers. As a result, students showed greater collaborative engagement, which is illustrated in the following script.

"AI helps me prepare comments before discussing with my partner, so I can give clearer feedback, ... when our group had different ideas, AI suggested alternative ways to combine them..." [S5]

"We use AI to validate our original idea. If the idea is similar to AI's suggestions, then we learn more about detailed information such as, ... But if it is different, we will further delve into some literature or ask our lecturer..." [S1]

These statements indicated that AI functioned as a collaborative problem-solver rather than replacing peer interaction. In classroom practices, students did not rely on the AI's output, but they utilised it as a mediating resource between peers, and they even requested the teachers' guidance or relevant literature investigation if they assumed that the AI's suggestions were not relevant or hallucination given their background knowledge.

Aspects of collaboration improvement revealed that AI promoted peer relationships by stimulating interactions during collaborative writing. Students described AI as a shared reference for topic discussion and feedback. Here, AI did not replace peer interaction, but AI facilitated collaborative discussion through alternative suggestions and writing recommendations, as indicated in the interview script as follows.

"I use AI to support our discussion about the writing task from my teacher. Once the topic is posted, my mate and I will discuss the topic, the outline of the topic, and the goal of the assignment. In the outlining phase, I usually open Gemini to look for insights, which I then discuss together..." [S5]

"...then, I use AI's suggestions in my discussion, and usually compare with my mates' outputs from ChatGPT's outputs..." [S3]

In addition to the two previous themes of interview data, AI assisted students in solving conflict resolution. Students indicated unequal participation and time management during peer interaction. By implementing a structured strategy of peer learning with AI integration, these conflicts were resolved effectively with teachers' monitoring throughout the writing process, as reported in the script as follows.

"AI helps me to complete my assignment since the tool offers several writing recommendations, so I can submit the tasks on time as scheduled with my mate." [S10]

"...at the beginning, I did not take part actively in our discussion because my mate always finished my assignment earlier once I open digital worksheet ... my teacher provide worksheet with member's contribution, so that I have to take my own for my contribution..." [S5]

Finally, the theme of seeking and offering help in peer collaboration demonstrated that AI enhanced students' confidence in both requesting and providing feedback. Students reported utilising AI in a collaborative digital workspace and serving as a proofreader for writing task refinement. This process encouraged more constructive feedback exchanges and reciprocal assistance with equal participation throughout assistance throughout the peer writing process, as evidenced in the following script.

"I use AI for feedback and insight generator ... that I am as proofreader of our assigned writing tasks..." [S12]

"In my Google Docs worksheet, I use Grammarly for grammar recommendations; then my peer uses QuillBot for content; after that, we proofread based on our own linguistics knowledge." [S6]

Interactional Processes (IP)

Interview data indicated that AI-enhanced collaboration changed the quality and organisation of peer interaction, participation quality, and feedback engagement. Students frequently conducted discussions, becoming more focused and substantive because AI-generated outputs provided a shared reference point for conversation among peers, as in the following interview statement.

"Before, we sometimes talked generally about the essay, but with AI suggestions we discussed specific sentences and arguments." [S8]

"AI gave us a starting point, but we still had to decide together which feedback to use." [S3]

These statements indicated that students applied structured collaborative dialogue by the use of AI tools. These platforms gave students evaluative insights, constructive feedback, and fruitful recommendations during student-students engagement.

The interviews also pointed out that students showed greater equal participation than in previous activities without structured and AI assistance. Students are reported to participate actively by the use of AI as their facilitating resource, as claimed by students in the following script.

"Although I was not confident in expressing my argument since I thought I was left behind with my peer. I can utilise AI to provide the feedback that ... of course I felt so happy to be an active student, and I had similar participation to my mate." [S2]

"I share my experience of using AI to help me provide suggestions; my peer follows my model; then we can discuss dynamically." [S9]

This finding demonstrated that AI integration in peer collaboration played a crucial role in connecting students gap by providing input, suggestions, and a buddy for problem-solving. In students' peer learning, the interactional process experienced dynamic, communicative, and interactive process among students. At the moment, teachers also play crucial roles as the facilitator, monitor, and guide academically and technologically during the teaching and learning process.

Ecological Perspective (EP)

From an ecological perspective, students presented the writing process as an emerging point from the interaction of technology, pedagogy, and peer collaboration within the digital classroom. Students described AI as one element within a broader learning ecology that included teacher guidance, peer discussion, and task design. In a digital learning environment, students demonstrated interconnected communication among AI tools, teachers, and other students, which drives them to apply peer collaboration effectively. Firstly, teachers provided structured scaffolding of activity and AI use for academic purposes; then AI tools were used as mediating resources to achieve classroom learning objectives, and students served as the central actors in classroom practices, as indicated in the following script.

"AI gave suggestions, but the teacher's scaffolding limits the AI's ethical use, and students' peer learning decided what we finally wrote,..." [S10]

"I can follow the model from the teacher about structured peer learning easily; if I don't understand, I will ask my teacher, even if I think the output of AI is not relevant..." [S7]

Another point of view is academic culture conducted by classroom members. It led students to critically use AI and be digitally aware of the ethical use of AI in academic settings. This condition benefits classroom atmospheres, not overreliance on AI output, as mentioned in the interview script as follows,

"Just AI outputs are only suggestions based on my prompt; I need to evaluate critically and connect the suggestions to relevant topics I learn." [S4]

"My teacher briefed us in the beginning session that AI only tools based my prompt, once we receive the output, learn it, connect it with what we understand, and accept/ reject using this output," [S11]

The ecological perspective finding reported that the teaching and learning process would be implemented effectively through the roles of teachers as the model actor and facilitator, students as the main actor to conduct the learning process, and AI as the third-party tool for providing learning perks to accomplish learning objectives.

Overall, the interview data showed that students need AI output in collaborative writing as a buddy that serves as a stimulant for students' critical thinking. Students were enabled to criticise AI's suggestions as the material for learning, evaluation, and negotiation in a peer learning activity. In classroom practices, students connected AI use, students' knowledge construction, and teacher guide into academic culture and collaborative writing practices. Therefore, AI-enhanced peer collaboration is perceived as the pedagogical scaffolding that offers benefits to class members through the roles of teachers, students, and technological tools in digital classroom environments. The affordances of interplay connection among three aspects afford a structured, socially mediated writing process where students retained responsibility for discussion, evaluation, and final writing decisions.

DISCUSSION

The findings of both quantitative and qualitative data reported an integrated, complementary, and mutually reinforcing positive pattern in this study. Quantitative data supported the alternative hypothesis, which demonstrated that there is a significant difference to intervention group who implemented AI-enhanced peer collaboration toward their writing skills. These results indicated that pedagogical mediation positively impacts students' performance. Moreover, the qualitative data also clarified the positive perceptions among students during their experience of the intervention, leading to students' writing improvement. In classroom practice experiences, AI served as an idea generator, peer feedback exchanger, collaborative problem solver, and reflective mediator. This current research finding aligns with a previous study by [Lin et al. \(2024\)](#), emphasising students' confidence, engagement, and interaction in the digital writing process. Furthermore, concerning the ecological framework, the study by [Rahimi \(2024\)](#) supports two aspects of qualitative data on the learning environment and academic culture in the technological space in digital learning.

AI-enhanced peer collaboration outperformed writing improvement across the intervention class rather than the control class. This implies that the AI integration into peer learning through structured collaborative writing processes offered deeper feedback engagement and crucial steps of the writing process accomplishment. From a pedagogical standpoint, these findings support sociocultural perspectives (Vygotsky, 1978) that emphasise writing as a social and cognitive activity among students. They are promoted to internalise knowledge construction through the social meaning of writing activities such as peer learning, feedback handling, and students' discussion. Connecting to the current condition, the peer collaboration serves as the social activity that builds students' cognition in writing knowledge, and AI contributes a mediational scaffold in response to teachers' guidance and mode. This model of peer learning is believed to help students conduct the writing process more effectively and efficiently (Chen et al., 2026; Lin & Hwang, 2025; Li et al., 2025).

Peer collaboration with AI utilisation contributes pivotal role in idea generation, writing assistance, and reflective engagement in writing class (Engeness, 2025; Guo et al., 2024; Song & Song, 2023). Students can implement well-organised, equal participation, and deeper engagement through AI mediation during the writing process (Lin et al., 2024). According to Zou (2025), AI tools assist students to refine students' grammatical challenges, adjustment provision, and offering textual alternatives to students. Essentially, these peer collaboration activities provide systematic procedures that offer writing reference sharing, equal participation among left-behind students and outstanding students, and booster of students' confidence in collaborative editing (Chen & Lee, 2022). To do so, AI tools provide technological resources to support students' learning process rather than replace the role of students.

In addition to quantitative findings, the second finding emphasised students' positive experiences of AI-enhanced peer collaboration during collaborative writing across multiple dimensions. During the peer collaboration and revision process of AI utilisation throughout collaborative writing, students reported better communication in delivering ideas and insights to their peers. AI provided social bonding to students through peer connection improvements, feedback sharing, and group communication dynamics. Moreover, utilising AI as a neutral third-party learning resource of optional resolutions, students demonstrated greater time management, high-quality participation, and writing style adjustment. In feedback handling and learning, boosting students' self-assurance with AI's assistance was also recommended to make them more ethical AI users. AI tools assisted students in maintaining interaction quality through targeted and substantive outputs from student-AI conversational prompting. Students also improved their critical reflection and feedback involvement with AI's outputs as AI, a technological tool, functioned as a mediator in a changing academic culture and digital learning ecosystem (Low & Van Ryzin, 2024).

The interplay among social-emotional learning (SEL), interactional processes, and ecological perspective in AI-enhanced peer collaboration highlights a multidimensional learning activity that is framed by emotional, social, and contextual

factors. According to [Ma et al. \(2025\)](#), dynamic and meaningful collaboration helps students to develop communication, empathy, conflict resolution, and relevant decision-making among classroom members. In classroom activities, students demonstrate balanced interactional engagement in a digital writing atmosphere, such as meaning negotiation, feedback sharing, and knowledge co-construction ([Peralta et al., 2025](#)). To promote students' emotional experiences in a great interactional process, AI and digital technologies mediate communication and facilitate teamwork among students ([Farinha & de Fátima Pina, 2024](#)). The ecological perspective sees the broader context of these interconnected factors where peer relationships, pedagogy, technology, and institutional culture are contextualising the addressed learning outcomes. Therefore, the previous findings from [Huang and Lajoie \(2023\)](#) and [Li et al. \(2023\)](#) corroborate that peer collaboration arises effectively when socioemotional competencies, interactional practices, and contextual conditions reinforce each other.

As part of the study's contribution to the emerging literature, the present study emphasises that AI integration into language learning reconceptualises new insights as the mediating resources in the collaborative and social learning process rather than individual cognitive support. With the teachers' systematic scaffolding, AI serves as a technological collaborator that bridges students with knowledge co-construction, deeper conversational engagement, peer scaffolding, and collective management of writing processes. This process promotes students' cognitive participation, social engagement, and writing development. Moreover, regarding the writing quality outputs, AI-powered tools improve students' writing quality, linguistic accuracy, coherence and cohesion, and linguistic awareness.

Despite the positive findings of the current study, several limitations emerge regarding AI-enhanced peer collaboration. The types of scaffolding and monitoring from teachers are urgently requested to respond to students' over-reliance on using AI in the digital classroom, while the onsite mode of learning activities sounds successful. Then, students' preparation and upskilling programs are needed to avoid a similar baseline of students' digital literacy and technological tool savvy so that left-behind students are avoided, and pedagogical intervention can be implemented as well as determined. To accommodate students' well-balanced socio-emotional learning in a collaborative writing environment, explicit scaffolding through dynamic material explanation, a reflective practice worksheet, and an e-collaborative workspace to support students' learning pace in outside-classroom activities.

CONCLUSION

This study demonstrates that students' writing skills and positive perceptions are notably affected by the implementation of AI-enhanced peer collaboration in EFL digital writing environments. The findings report that socio-emotional learning, interactional processes, and ecological perspective are influencing factors toward the successful implementation of the text quality of students' composition. In classroom activities, AI plays role as a mediating resource that promotes collaborative

autonomy, dynamic engagement, and communicative peer interaction. To perform writing development in digital contexts, dynamic interplay integration among students, peers, instructional design, and technology mediation is emphasised in the teaching and learning process.

Despite the promising findings, several limitations are recognised to improve the upcoming research. First, the present study is not supposed to generalise findings since the research was conducted in a short time period and particular educational settings. Additionally, the study employed research instruments to collect data limited to investigating how students' writing progress is influenced by AI-enhanced peer collaboration; the study did not distribute the research procedures on how the pedagogical intervention affects students across student demographics, skill levels, and institutional contexts.

The forthcoming research is recommended to delve into broader educational levels with meaningful and various research instruments to enhance its validity and reliability. The research is demanded to assess direct influencing and mediating factors using SEM rather than simple statistical tests to enrich the findings and detailed exploration of the study. To support the quantitative data, the qualitative data collection of classroom observation and field notes is requested to capture meaningful phenomena in digital classrooms. Another research is needed on the research-based design for the development of AI integration into pedagogical collaborative writing rather than utilizing AI as an ecological factor that boosts the students' writing efficacy. Additionally, an upskilling program for professional development should offer initiation to respond to students' digital literacy, teamwork skills, and critical interaction, which offer cognitive, social, and affective benefits.

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CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest.

AUTHOR(S) CONTRIBUTION

Ratnawati: Data collection and analysis, writing original draft, preparation, writing revision and editing, writing-responses to reviewers' comments. **Fitriyah:** Conceptualization, research preparation partly, supervision, writing-responses to reviewers' comments. **Juitania:** Research preparation partly, resources, data collection coordinator. **Moh. Thoyib Syafi'i:** Methodology, supervision, data validation.

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