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Impact of The Integration of Generative AI-Automatic Corrective Feedback on Academic Writing Skills

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Abstract. This study aims to investigate the impact of using Gen AI-automatic corrective feedback (ACF) on students' academic writing ability. The research method used in this study was a quasi-experiment involving 250 high school students. Participants were divided into two groups with the same number, namely the experimental group was the class which received ACF (electronic) and the control group, which received manual corrective feedback (non-electronic). Both groups received interactive writing activity guidance based on the principles of activity theory by utilising aspects of collaboration, social environment, electronic and non-electronic mediation. Data analysis used ANCOVA to investigate the impact of both interventions on academic writing ability. The results showed that the group that received integration of the Generative AI-ACF intervention in writing learning was able to improve academic writing ability more effectively than traditional writing learning. The improvement of academic writing ability is seen in the quality of writing that is able to meet several aspects, including achievement of task, cohesion, coherence, range and grammatical accuracy, and lexicon. This improvement occurs because of several contributions from ACF, including clear error identification, the use of adaptive metalinguistics, and direct feedback, as well as a comprehensive feedback focus. This shows that ACF is able to optimise students' behaviour, cognitive, and affective aspects that indicate students' willingness to improve their academic writing skills. This study implies that the integration of the use of technology in writing learning can help teachers optimise writing skills because some of the focus of teachers' concentration in improving the quality of students' writing is assisted by technology.

Keywords: academic writing skills; activity theory; Gen AI-automatic corrective feedback (ACF); writing learning

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1. Introduction

Technological developments in language learning currently focus on improving the quality of the writing learning process because writing skills are one of the most needed skills in secondary and tertiary schools (Polakova & Ivenz, 2024; Zhao et al., 2024). There are several technologies in various forms, such as platforms, web, applications, and one of the AI Gens. Currently, the use of AI Gens in the learning process is increasingly intense because the benefits and competencies produced are increasingly better and more effective (Mohammed & Khalid, 2025). One of them is the use of Chat-GPT and automatic corrective feedback (ACF). Both AI Gens are the most frequently used AI in writing learning. Automatic Corrective Feedback (ACF) is an online programme used in writing learning to provide feedback and comments to improve the quality of a piece of writing (Polakova & Ivenz, 2024; Wu et al., 2020). Students can send writing to the ACF platform and get feedback from teachers or other students by paying attention to cohesion and coherence, lexicon, and range and accuracy of grammar (Thi & Nikolov, 2023; Yang et al., 2024). This ACF platform is carried out electronically, directly, and consistently to address student difficulties. Automatic corrective feedback (ACF) is used based on objective rules and norms to improve the quality of writing. In contrast, corrective feedback is based on the style, preferences, subjectivity, and abilities of each teacher and student interacting with the feedback (Hadianto et al., 2022; Yan & Zhang, 2024). This ACF platform is more standardised and consistent in all types of writing than human assessments. The feedback generated is also excellent quantitatively and qualitatively and provides more opportunities for improvement and editing to improve the quality of student writing.

This ACF platform has the same limitations as other applications: time constraints. However, it has many advantages, including helping teachers to provide feedback that is not too focused on aspects of grammar, punctuation, and spelling, because this platform can provide comprehensive feedback on these components, so that teachers can focus more on writing skills holistically, such as aspects of content and organisation of writing (Mohammed & Khalid, 2025; Zou et al., 2022). In addition, this platform also sometimes provides suggestions that are not in accordance with the context of the writing because this platform cannot comprehend the intent, style, and context of the writing. Several previous studies have investigated the impact of ACF platforms. The results of previous studies have shown that ACF has proven effective in improving students' essay writing skills (van Heerden & Bharuthram, 2021; Zhang et al., 2023). However, previous studies have not been optimal in investigating the impact of the online feedback dimension feature. In addition, no studies have investigated the impact of ACF on academic writing skills that pay attention to aspects of task achievement, cohesion, coherence, range and grammatical accuracy that can improve the quality of students' writing. Moreover, elements of student engagement in the learning process—such as behavioural (application, enhancement), cognitive (focus and comprehension), and affective (positive or negative views) aspects—are thought to play a significant role in students' writing abilities and have not been thoroughly examined in ACF research (Jiang et al., 2021; Lu & Xie, 2019). The results of the current study are believed to produce findings that contribute more

to writing skills and improve understanding of students' behaviour, cognitive, and affective that can contribute to writing skills.

The current study focuses on using the ACF platform to optimise students' active participation in writing learning and explore students' behavioural, cognitive, and affective aspects that contribute significantly to writing ability. Academic writing ability in this study includes aspects of task achievement, cohesion and coherence, lexicon, range and grammatical accuracy (Khosravi et al., 2023; Mohammed & Khalid, 2025). Furthermore, elements of writing accuracy, grammar, punctuation, spelling, and writing conventions are also examined. The current study comprehensively investigates the impact of the ACF platform on various aspects of writing. The current study's findings can provide knowledge about the use of the ACF platform in developing students' organisation and logic and investigate the effectiveness of this ACF platform in improving the accuracy of sentence structure and grammar. This study also provides an understanding of student interactions in providing feedback responses through technology media and comprehensive insights into students' behavioural, cognitive, and affective aspects when using the ACF platform.

2. Literature Review

2.1 Activity Theory

This study uses activity theory in the learning process. This theory optimises student interactions, social contexts, and the necessary scaffolding. This theory emphasises that environmental factors can facilitate students to engage in various interactive activities to achieve learning goals (Huang & Jun Zhang, 2020; Wu et al., 2020). This theory states that six aspects can encourage students: subjects, objects, scaffolding media, groups and task division. Subjects are students who actively participate in language learning activities and share their experiences and abilities in interactive language learning activities. Objects are learning goals, such as writing or speaking skills. Scaffolding is a student's media or platform in interactive language learning, such as online applications (Hadianto et al., 2021; Yang et al., 2024). Groups are the social environment where interactive language learning activities take place. Norms govern the process of interactive language learning activities, such as class rules or language ability criteria. Task division is the division of roles and responsibilities for students in learning groups (Selwyn & Renaud-Assemat, 2020; Shahsavar & Asil, 2019). These aspects have a reciprocal relationship to present various interactive learning activities to achieve learning goals (Noroozi et al., 2024; Xu et al., 2019). In the current study, students were presented with an electronic learning process, namely writing learning using AI-ACF and a non-electronic class that uses traditional writing learning methods. Both types of classes involve students in interactive writing learning activities to improve academic writing skills within a community of students and teachers.

Students in the learning process are responsible for sharing ideas and suggestions in developing writing assignments needed during interactive and individual learning activities. In non-electronic classes, corrective feedback activities are also provided manually by teachers to help students improve their academic writing skills in the control group. Subscale analysis in both electronic and non-electronic class groups was carried out on the interaction and reciprocity of all elements that

interact in the writing learning process, including subjects (students), objects (writing learning objectives), scaffolding media (ACF and traditional platforms), and rules (norms or guidelines) (Ebadi & Rahimi, 2018; Svensson et al., 2021). In this study, researchers analysed the differences or conflicts that emerged in each aspect. These conflicts are likely to arise during the implementation of the learning process, such as inconsistent, non-optimal involvement of student participation, differences in results, inappropriate roles, and actual contributions from both types of classes. This study investigated factors that can facilitate or inhibit practical collaborative writing activities. Knowledge of conflicts that may arise in aspects of the writing learning process is essential to find potential obstacles to the activity system so that improvements can be made to writing teaching practices.

2.2 Automatic Corrective Feedback

Automatic corrective feedback (ACF) is one of the AI Gens that can be used as a scaffolding medium to provide corrective feedback and improve the quality of students' writing (Chan et al., 2025; Elfeky & Elbyaly, 2021). Current writing studies use AI and other technologies adopted in writing learning. This ACF is used in the writing learning process to help students overcome problems related to aspects that can improve the quality of writing, such as grammar, punctuation, spelling, and conventions, as well as providing time to improve students' writing (Asghar et al., 2023; Fälth & Selenius, 2024). Students also get appropriate and consistent metalinguistic explanations that can help students improve the accuracy of their writing and help teachers anticipate limited time. Feedback on writing errors also facilitates students to focus more on mistakes so that improvements can be made effectively. Several previous studies reveal various online corrective feedback platforms. Previous studies have shown that automatic feedback using the AWE online platform contributes significantly to essay writing skills in organising ideas and using grammar (Polakova & Ivenz, 2024; Thi & Nikolov, 2023; Yang et al., 2024). Furthermore, another study revealed that the Write & Improve online platform can produce diagnostics of students' writing abilities according to the level of the Common European Framework of Reference (CEFR) scale accurately and can facilitate students to complete essay, report and argument writing tasks with good quality (Evmenova et al., 2024; Kim et al., 2024). In addition, another study revealed that the AWE platform can contribute significantly to grammatical accuracy and other dimensions of writing performance, such as task achievement, cohesion, coherence, and lexicon, as well as active student participation.

Furthermore, the CorrectEnglish online platform has been proven effective in improving students' essay writing skills regarding grammar, writing style, and word usage. This platform provides feedback on students' writing regarding content, organisation, style, writing focus, and overall writing skills (Yu & Xu, 2024; Zou et al., 2022). In addition, there is also a previous study that examined the effectiveness of ACF on argumentative essay writing skills. The study results showed that feedback through ACF can improve the quality of argumentative essay writing in terms of organisation and grammar (Ebrahimi & Ebadi, 2024; Mohammed & Khalid, 2025). This study differs from previous studies; the current

study focuses on academic writing skills by considering aspects of task achievement, cohesion and coherence, lexicon, range and grammatical accuracy that can improve the quality of students' writing. In addition, this study also investigated aspects of student involvement in the learning process, which include behaviour (application, improvement), cognitive (attention and understanding) and affective (positive or negative perception), which are believed to contribute significantly to writing skills. This study's findings are expected to provide comprehensive information for instructional practices, language curriculum development, and technology design in language learning. Based on the explanation, the researcher formulated the following problems:

a) How is the impact of Gen AI-ACF integration in writing learning on academic writing skills?
b) How is the impact of Gen AI-ACF integration in writing learning on students' behaviour (application, improvement), cognitive (attention and understanding) and affective (positive or negative perception)?

3. Methodology

3.1 Design and Participants

The research method used in this study is a quasi-experiment to test Gen AI-ACF in improving students' academic writing skills. This study involved 250 high school students divided into two groups: the experimental group (feedback intervention group with ACF) and the control group (traditional feedback group). The experimental group in this study is also called the electronic class, while the control group is also called the non-electronic class. Writing assessments were carried out in the pretest and post-test phases in both groups. Participants involved in this study were from grades 10-12 of high school, with an age range of 17-19 years, and a gender composition of 60% female and 40% male students. The sample selection was carried out randomly and divided into two groups with 125 students each in the experimental group (electronic class using ACF and the control group (non-electronic class or traditional class). The assignment was carried out randomly to reduce potential bias and increase the reliability and validity of the findings. Language skills in both groups were at level B1 or intermediate according to CEFR standards to ensure homogeneous data of the participants involved. In addition, a test was conducted to reveal initial variations. The analysis results found no initial variations in writing competence in both groups.

3.2 Procedure of Intervention in Both Groups

3.2.1 Writing learning with generative AI (ACF)

Learning in the experimental group, an electronic class, is carried out through several stages. Students are given a writing topic to plan for, using various strategies, such as writing with a predetermined topic and discussing it between students at the pre-writing stage. Students complete their draft writing and submit it to the teacher first to get input on the main problems in writing essays. The main writing problems highlighted by the teacher are aspects of task achievement, cohesion, coherence, and writing organisation. The next stage is collaborative revision, where students discuss, provide suggestions, and make decisions based on feedback. This collaborative revision process aims to improve

understanding of writing strategies and conventions. Students first revise their essay writing based on the collaborative revision discussion and then post their writing on the ACF online platform. The last stage is the individual revision phase, based on the feedback received based on ACF, which includes grammar, punctuation, spelling, and other problems. At the end of each writing assignment, the teacher evaluates the final writing using descriptors to analyse it. The integration between collaborative and individual revision aims to improve the quality of students' writing comprehensively from various aspects. This collaborative improvement process is part of integrating the collaborative learning environment to enhance the quality of students' writing. This collaborative revision goes through several stages and involves students and teachers to provide feedback and encourage active student participation in improving the quality of writing.

3.2.2 Writing with traditional feedback (control group or non-electronic classes)

The control group also carries out academic writing learning on the same topic. Students in this traditional class go through several stages, namely as follows. Students go through the pre-writing stage by completing the first essay draft and submitting it to the researcher to get feedback on the main writing aspects first. After improvements are made to the main writing aspects, students are asked to write a second draft and submit it to the teacher for manual feedback. Students improve the essay draft based on input from the teacher and prepare the final draft. Almost the same as the experimental class, the teacher marks the draft based on the CEFR descriptor on each writing assignment. The intervention in both groups was carried out for one semester with two sessions each week. Each session lasted 100 minutes, with five collaborative writing tasks each during the intervention.

3.3 Research Instrument

3.3.1 Academic writing task

Writing ability evaluation was conducted through academic writing tasks 1 and 2 in both groups. These two types of functions were conducted in the form of essays and assessed using the CEFR writing descriptors. The evaluation was conducted in four aspects, namely task achievement (decomposition of main points, the presence of an overview, factual data, and the number of words meeting the criteria), cohesion and coherence aspects (organisation of ideas, paragraph format, and conjunctions), lexicon aspects (use of terminology, collocation, and sentence use), range and accuracy of grammar (use of grammar, punctuation, and errors). Each aspect in the assessment was scored from 1 to 9 points. In the task achievement aspect, point 9 indicates that the task is fulfilled by presenting a claim position, expanded by various ideas, and reinforced by data. In the cohesion and coherence aspect, point 9 indicates the use of correct and effective cohesive devices and structures. The lexical aspect point 9 indicates the use of appropriate vocabulary and the incorporation of proper idioms.

Regarding grammatical range and accuracy, point 9 shows the use of flexible structures and minimal errors that do not interfere with understanding. The teacher assesses each student's academic writing ability with a percentage of 40% of academic writing assignments and 60% of academic writing assignment 2. The

final score is taken from the sum of the two writing assignments, with values varying from 1 to 9 multiples of 0.5. Agreement between assessors is carried out so that the subjectivity of the assessment can be minimised. The analysis results found an agreement that met the criteria of both assessors, with a value (r = 0.84).

3.3.2 Stimulated memory

The assessor used the stimulated memory technique to assess students' behavioural, cognitive, and affective aspects while participating in the writing learning process with ACF. This technique was carried out on 10 people from the participant sample in the experimental class. Samples with this technique were taken from representatives who got relatively low, medium, and high scores in the post-test phase. This technique is used based on research ethics involving human participants. Before implementing this stimulated memory session, selected students received a consent form so that student participation was voluntary. The names of the participants are anonymous, and the data is only used for research purposes. Students' activities during the learning process were recorded using screen recording, and follow-up interviews were also recorded and analysed to maintain data accuracy. Before the interview, students watched a video recording of them working on their writing and received online feedback to improve the quality of their writing. Students were instructed to recall the behavioural, cognitive, and affective aspects that emerged during the process. Some were asked to reveal these aspects, for example, "Why did you accept and use the corrective feedback results? "Why didn't you accept the feedback results and didn't apply them? All of these questions facilitated researchers to obtain data on students' ideas and motivations in writing. To help students remember all activities during the learning process, researchers also displayed screen recordings of students' interactions with the ACF platform online. Interviews were conducted for 60 minutes and transcribed for data analysis. The validity and reliability test of the stimulated recall data used member checking techniques by returning the interview results to students who participated in this session to ensure whether they were accurate. In the final session, students had the opportunity to ask questions about the learning process they had followed.

3.3.3 Interview

Next, interviews were conducted with individual student representatives in the experimental group to reveal students' attitudes and perceptions of the effectiveness of ACF use. Students were asked to clarify the writing skills that had improved in the post-test phase. The researcher revealed aspects of writing skills that were influenced by using the ACF platform. Interviews were conducted with the same participants in the previous session using the stimulated memory technique to ensure consistency and coherence. This interview was also conducted to comprehensively understand the learning process's behavioural, cognitive, and affective aspects. Interviews can also minimise the potential for foreign factors influencing the data.

3.4 Data Analysis

The Kolmogorov-Smirnov test in the pretest and post-test phases was conducted to test the normality of the data. The test results showed that the data for both groups were normal. Furthermore, a one-way ANCOVA parametric test was used to compare the writing skills of the two groups by considering aspects of task achievement, coherence and cohesion, lexicon, and grammatical range and accuracy.

4. Result

Descriptive statistical analysis was used to analyse the average scores in the pretest and post-test phases of writing skills. The study was conducted on each aspect that improves the quality of writing, including task achievement, coherence and cohesion, lexicon, range and grammatical accuracy in both groups. The results of the analysis are presented in Table 2. Based on the analysis results, both groups' scores in the pretest phase showed the same writing ability in task achievement, coherence and cohesion, lexicon, range and grammatical accuracy. However, in the post-test phase, the experimental group (electronic class) scored better than the control group (non-electronic class).

Table 1: Text codes of each identified theme

Coding process	Sample coded texts	Contoh
Open thematic coding	Providing immediate feedback	P5: I like it and find it meaningful because I can check my writing mistakes and get feedback quickly. After a while, it also helped me to know the common mistakes, and it helped me to fix some old mistakes.
	Identifying writing weaknesses	P3: In saying I have become very dependent on this AI technology … The fast feedback helps me to understand my mistakes and weaknesses better, and becomes a lesson not to repeat them.
	Providing explanations	P2: This AI technology provides simple and useful explanations and samples that help me to develop my writing skills.
	Revising own writing	P1: It is very interesting to make me able to revise my own text quickly and effectively.
	Increasing self-confidence	P1: I can say that this AI can increase my confidence and motivation in writing because my mistakes have been checked and corrected.
Axial coding (Theme grouping) Theme categorisation	1) Finding weaknesses in writing 2) Revising one's own writing 3) Increasing self-confidence 4) Organising one's own writing	

Table 2: Results of descriptive statistical analysis of the pretest and post-test phases

	Group	N	Mean	Std. deviation	Std. error mean
Pre-writing skills	Experiment	125	5.43	0.85	0.21
	Control	125	4.31	0.83	0.20
Post-writing skills	Experiment	125	7.86	1.10	0.21
	Control	125	5.24	1.02	0.20
Pre-task achievement aspect	Experiment	125	4.35	0.83	0.15
	Control	125	4.32	0.82	0.16
Post-task achievement aspect	Experiment	125	6.24	1.31	0.25
	Control	125	5.35	1.08	0.22
Pre-coherence and cohesion aspect	Experiment	125	4.05	0.78	0.15
	Control	125	4.01	0.83	0.17
Post-coherence and cohesion aspect	Experiment	125	6.21	0.81	0.14
	Control	125	4.76	1.07	0.22
Pre-lexicon aspect	Experiment	125	4.42	1.06	0.20
	Control	125	4.35	1.30	0.27
Post-lexicon aspect	Experiment	125	7.46	1.03	0.20
	Control	125	5.31	1.42	0.28
Pre-grammatical range and accuracy aspect	Experiment	125	4.51	0.73	0.13
	Control	125	4.26	0.80	0.16
Post-grammatical range and accuracy aspect	Experiment	125	7.24	1.31	0.23
	Control	125	5.35	1.03	0.22

A one-way ANCOVA test was conducted to investigate significant differences between the experimental and control groups in improving writing skills in each aspect. The results of the ANCOVA analysis of the overall writing skills of both groups, controlling for pretest scores, are presented in Table 3. Based on the analysis results, a significant difference was found in the post-test scores of the writing skills of both groups. The experimental group showed better writing skills than the control group with a value of [$F(1, 55) = 48.30$, $p < 0.00$, $\eta p\ 2 = 0.50$]. Furthermore, one-way ANCOVA analysis was conducted to investigate differences in writing skills in each aspect, starting from the task achievement aspect of the two groups. The analysis results on the task achievement aspect, controlling for pretest scores, are presented in Table 4. The results of the analysis showed that there was a significant difference between the post-test scores of the task achievement aspect in both groups, with a value of [$F(1, 55) = 3.82$, $p < 0.05$, $\eta p2 = 0.07$]. This value states that the writing skills of the task achievement aspect of the experimental group are better than those of the control group.

Furthermore, a one-way ANCOVA test was also conducted to investigate differences in writing ability in the aspects of cohesion and coherence. The results of the ANCOVA analysis of the cohesion and coherence aspects are presented in Table 5. Based on the results of the analysis, there was no significant difference between the post-test scores of the cohesion and coherence aspects in both groups, with values [$F(1, 55) = 1.45$, $p < 0.25$, $\eta p2 = 0.03$].

Table 3: Results of the ANCOVA analysis of differences in writing ability in both groups

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Pre-writing performance	46.00	1	46.00	163.42	0.00	0.81
Groups	14.42	1	14.42	48.30	0.00	0.50

Table 4: Results of ANCOVA analysis of writing quality for the task achievement aspects of both groups

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Pre-task achievement	10.82	1	10.82	8.62	0.00	0.14
Groups	5.72	1	5.72	4.81	0.06	0.07

Table 5: Results of ANCOVA analysis of writing quality in terms of cohesion and coherence for both groups

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Pre-coherence and cohesion (covariates)	32.41	1	32.41	120.73	0.00	0.72
Groups	0.40	1	0.40	1.54	0.31	0.03

Table 6: Results of ANCOVA analysis of differences in writing quality in terms of lexicon aspects of the two groups

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Pre-lexicon (covariates)	28.21	1	28.31	28.27	0.00	0.43
Groups	0.51	1	0.52	0.50	0.51	0.00

Table 7: Results of ANCOVA analysis of differences in writing quality in terms of range and grammatical accuracy of the two groups

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Pre-grammatical range and accuracy (covariates)	31.72	1	29.78	37.05	0.00	0.40
Groups	48.20	1	50.21	58.40	0.00	0.65

One-way ANCOVA test was also conducted to investigate the differences in writing ability in the lexicon aspect of the two groups in the post-test phase. The results of the analysis are presented in Table 6. Based on the results of the study, there was no significant difference in the post-test scores in the lexicon aspect of the two groups with a value of [$F(1, 55) = 0.51$, $p < 0.50$, $\eta p2 = 0.00$]. This result confirms that the lexicon aspect of the two groups showed an increase that was not much different. Finally, a one-way ANCOVA test was conducted to investigate the differences in writing ability in the two groups' range and grammatical accuracy aspects, involving the pretest scores. The results of the analysis showed that there was a significant difference in the post-test scores in the range and grammatical accuracy aspects with a value of [$F(1, 55) = 58.40$, $p < 0.00$, $\eta p2 = 0.65$]. This result confirms that the experimental group or electronic class showed better writing ability in every aspect than the control group or non-electronic class. Next, cognitive engagement analysis was conducted to obtain an overview of students' understanding of the use of ACF in improving their writing skills. The analysis included using students' cognitive processes in receiving feedback and deciding to make appropriate improvements and students' metacognitive processes in controlling students' mentality. Excerpts from students' responses that showed students' ease in recognising feedback and input received from the platform, due to writing errors, were marked. Understanding the causes of errors provided by ACF facilitated students in correcting mistakes. This process shows that cognition is involved in the use of ACF in the aspects of paying attention and students' understanding. However, some participants made decisions not to change their writing. Students' cognitive behavioural responses are presented in Tables 9 and 10, as well as examples of student responses that did not understand the results of feedback from ACF. Example P6 was able to identify the results of corrections from feedback, but did not understand the nature of the feedback. So, P6 is involved in the cognitive aspect of ACF at the level of paying attention, but it is not yet understood.

Table 8: All learners' behavioural engagement with ACF

Error	ACF frequency	Accurate ACF		Inaccurate ACF	
		Accept	Reject	Accept	Reject
Time adverbs	7	5	1	1	
Verbs	15	7	1	5	1
Subject-verb agreement	10	5	1	4	1
Diction	9	4	1	4	1
Articles	36	12	3	13	2

Error	ACF frequency	Accurate ACF		Inaccurate ACF	
		Accept	Reject	Accept	Reject
Sentences	15	6	2	4	2
Active/passive verbs	5	3	1	2	
Clauses	10	7	1	2	1
Spelling	22	16	1	2	1
Punctuation	12	9	1	2	
Prepositions	9	8		1	
Writing conventions	17	13	1	3	1
Total number of errors	160	86	17	42	16
Percentage	100%	56.83%	11.45%	24.70%	10.67%

Table 9: Examples of P3 and P6's cognitive engagement with AI-ACF

Sample feedback	Question	Student's response
However = Though	Why did you accept this corrective feedback and use it?	Actually, I had learned about contrasting conjunctions and I knew I should use a comma after "however". When I saw the feedback online, I immediately knew I had made a mistake. (P3)
Most studies have investigated = Most of studies has investigated	Why did you reject this corrective feedback and not use it?	The feedback showed "has should be become have" … but this feedback was contradictory because the subject is "a most" which requires a singular verb! So, I didn't use it. (P6)

5. Discussion

The current study attempted to investigate the impact of Gen AI-ACF on academic writing skills. The study's findings showed that students in the experimental group who received the Gen AI-ACF intervention could improve their academic writing skills better than students in the control group who received a traditional writing learning intervention. The study's results align with previous findings, revealing that Gen AI-ACF can improve essay writing skills, especially in enhancing writing accuracy (Khosravi et al., 2023; Zhang et al., 2023; Zhao et al., 2024). This improvement in academic writing skills occurred because the experimental group received two sessions of direct input from the teacher and ACF, significantly impacting students' writing skills. Previous studies also reinforced this, which found that ACF provides comprehensive and synchronous metalinguistic feedback explanations (Thi & Nikolov, 2023; Yan & Zhang, 2024). Through this process, students increase their attention and awareness of errors in writing so that improvements are made more effectively. In contrast to traditional writing learning, which receives manual feedback, it does not receive comprehensive feedback.

Further findings on each aspect of the experimental group's writing skills generally show better scores than the academic writing skills of the control group. However, there was no significant difference in the aspects of cohesion, coherence and lexicon in the two groups. This finding aligns with previous studies that confirmed that students who received online feedback showed better writing quality than those who received manual feedback using paper regarding

grammar and accuracy (Polakova & Ivenz, 2024; Yang et al., 2024). This finding indicates that online feedback significantly contributed to writing accuracy, but in terms of cohesion, coherence, and lexicon, online feedback was of the same quality as traditional feedback. The finding that automatic corrective feedback significantly impacts writing accuracy is also supported by previous studies showing that students who received feedback through ACF immediately corrected their writing errors, improving their writing accuracy (Evmenova et al., 2024; Thi & Nikolov, 2023; Yu & Xu, 2024).

The improvement of writing ability in terms of task achievement through ACF occurs because ACF helps students to save time and focus on high-level feedback aspects in their writing drafts, so that students can complete their writing better. This finding is in line with previous studies that revealed that using online feedback applications as feedback tools helps teachers focus more on the main problems of writing and contributes more to the quality of writing (Mohammed & Khalid, 2025; Peungcharoenkun & Waluyo, 2023). Unlike traditional classes, time constraints make it impossible for teachers to focus on aspects of writing ability such as accuracy and grammar. This finding is supported by several benefits of ACF, including the fact that ACF feedback can be received immediately by students, making it easier for students to correct mistakes immediately. ACF also creates a learning environment that can improve academic writing skills more effectively (Latifi et al., 2023; Thi & Nikolov, 2023; Zhao et al., 2024). The effectiveness of ACF in improving academic writing skills is also supported by the linguistic explanation in the ACF application that encourages students to look for other references from the ACF, thereby contributing to students' academic writing skills (Yang et al., 2024).

Based on activity theory, ACF is a media scaffold that can substantially contribute to writing skills. This ACF highlights language, writing conventions, and metalinguistics and provides an overview of errors in writing. Based on its role, the ACF application can regulate students' academic writing skills by providing students with what they need and facilitating students to internalise their writing skills. Group learners can also help students share writing ideas and work together to improve their writing. The ACF application helps students gradually shift their writing activities from regulated to independent writing activities. This finding aligns with Engeström's (1987) activity theory, which states that various meaningful learning activities will help students become independent learners (Kao & Reynolds, 2024; Zhao et al., 2024). Students who use ACF can achieve self-regulation and writing automation levels more effectively and efficiently than students who learn with traditional learning methods. This finding aligns with previous studies that reveal that technology-assisted or online language learning can facilitate students to achieve self-regulation compared to learning using conventional methods (Evmenova et al., 2024; Mohammed & Khalid, 2025).

These quantitative findings are also reinforced by qualitative findings that confirm that ACF can facilitate students‘ engagement in learning activities that achieve self-regulated writing activities. Writing guidelines in the learning process with ACF can create an interactive learning environment between students, teachers, ACF, and the classroom environment. Strong correlations

between elements in various dimensions of various writing activities contribute significantly to self-regulation and writing automation. This is different from the control group of feedback carried out manually, which produces a weaker correlation and limited time to participate actively, so it cannot achieve self-regulation and writing automation. Another qualitative finding is that students are optimally involved in behavioural, cognitive and affective aspects. Students who have poor writing skills will receive all feedback from ACF that is considered appropriate and inappropriate. Conversely, students with good writing skills will only correct appropriate errors and ignore some of them. This indicates that ACF can optimise students' cognitive and affective behaviour, showing their willingness to improve their academic writing skills. This finding aligns with previous studies, which revealed that most students will use their linguistic abilities and conform with the feedback provided by ACF (Parker et al., 2024; Thi & Nikolov, 2023; Yang et al., 2024). Another study also supports this finding that students receive feedback but do not use all suggestions to improve their writing because of their linguistic knowledge, so students think critically about the suggestions given (Polakova & Ivenz, 2024; Zhao et al., 2024). Students can effectively improve their writing based on metalinguistic abilities and ACF feedback.

6. Conclusion, Implications, and Recommendations

Generative AI (Automatic Corrective Feedback) integration in writing learning can improve academic writing skills more effectively than traditional writing learning. Improvement in academic writing skills is seen in the quality of writing that can meet several aspects, including achievement of cohesion tasks, coherence, range, grammatical accuracy, and lexicon. In addition, writing learning using ACF can optimise students' behavioural, cognitive, and affective involvement, and most students show positive attitudes and perceptions towards using ACF in writing learning. This increase occurs because of several contributions from ACF including clear error identification, use of adaptive metalinguistics, and direct feedback, as well as the focus of feedback not only on the main problems (content, organisation of ideas, style, writing focus, and overall writing skills) but also other aspects of writing such as task achievement, cohesion, coherence, range and grammatical accuracy, and lexicon. Students with poor writing skills will receive all feedback from ACF that is considered appropriate and inappropriate, so that their writing skills improve. Likewise, students with good writing skills will correct only the appropriate mistakes and ignore some of them. This indicates that ACF can optimise students' cognitive and affective behaviour, showing their willingness to improve their academic writing skills.

This study implies that adopting technology in writing learning can help teachers optimise writing skills because some of the teachers' focus on improving the quality of students' writing is assisted by using technology. In addition, integrating technology in writing learning optimises the involvement of students' behavioural, cognitive, and affective aspects in writing so that it can contribute significantly to writing skills. This study has several limitations, including the absence of accurate confirmation or not yet the results of the feedback generated by the application, the number of samples that are still limited in scope or focused

on one school level, the absence of investigations into other competencies that contribute to writing skills, such as critical thinking skills in receiving feedback either manually or automatically, the lack of exploration of the involvement of cognitive and affective behavioural aspects in students who receive feedback traditionally using paper. Based on the limitations of the study, the researcher recommends several suggestions for future research, including the need for a feedback confirmation session to optimise students' critical thinking skills in receiving and selecting the feedback received, the sample needs to be expanded to the college level, there needs to be an investigation into students' critical thinking skills that may contribute to students' academic writing skills, and there needs to be an exploration of behavioural, cognitive, and affective aspects in students who learn using conventional methods.

7. References

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