



Artificial Intelligence as a Digital Linguistic Scaffold in Higher Education: Evaluating ChatGPT-Assisted Revision for Enhancing Second-Language Academic Writing

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Abstract. Within the evolving digital learning ecosystems, artificial intelligence technologies are increasingly being embedded into pedagogical practices to enhance teaching–learning experiences and improve measurable academic outcomes. Large language models such as ChatGPT have created new possibilities for real-time feedback, iterative revision, and individualized linguistic support in second-language writing instructions.

Contextualised by established theories of Second Language Acquisition (SLA), particularly the sociocultural theory of Lev Vygotsky, Stephen Krashen’s Input Hypothesis, and Merrill Swain’s Output Hypothesis, the present study investigates how AI-assisted feedback can function as a digital linguistic scaffold in second-language academic writing. Employing a mixed-methods research design, the study was conducted with sixty-four second-year engineering students enrolled in an English for Professional Purposes course. Participants first produced initial writing drafts independently and subsequently revised their texts using AI-mediated feedback generated by ChatGPT.

To evaluate the impact of AI-assisted revision, pre- and post-intervention drafts were analysed using the corpus-analysis platform Voyant Tools to examine vocabulary density, lexical distribution, and readability indices. Statistical comparison of the datasets reveals a statistically significant improvement in vocabulary density, lexical diversity, and readability scores in the revised drafts, indicating enhanced syntactic clarity, lexical diversity, and overall textual coherence. Qualitative reflections from

participants further suggest that AI-generated feedback encouraged iterative revision, strengthened metacognitive awareness, and fostered greater learner autonomy during the writing process.

The findings demonstrate that AI-driven writing tools can function as effective pedagogical scaffolds within digitally mediated learning environments and support Outcome-Based Education through data-driven evaluation of learning outcomes in second-language writing instruction.

Keywords: Artificial Intelligence in Education, ChatGPT, Second Language Writing, Digital Learning Ecosystems, Linguistic Scaffolding, Corpus-Assisted Analysis, Higher Education

1. Introduction Advanced digital technologies have reconfigured the educational practices across the globe. The revolution recreates how knowledge is accessed, created, and communicated. Among these developments, Artificial Intelligence (AI), the modern miracle has emerged as one of the most influential innovations in contemporary education, offering unprecedented opportunities for personalized learning, adaptive instruction, and immediate feedback (Holmes et al., 2022; Kasneci et al., 2023; Zawacki-Richter et al., 2019). The ability of the generative AI tools particularly like ChatGPT to interact with learners producing human-like responses, explaining concepts, and supporting complex cognitive tasks has accelerated this advancement and transformation further. As a result, educators and researchers are increasingly exploring the pedagogical implications of AI-mediated learning across diverse educational contexts (Godwin-Jones, 2023; Tlili et al., 2023).

Exceptional results have been produced when it comes to second language learning. The significance of these developments is particularly evident in second-language (L2) writing instruction. Writing is regarded as one of the most demanding language skills as it requires learners to simultaneously manage vocabulary, grammar, coherence, organization, and audience awareness (Hyland, 2019; Ortega, 2009). For many L2 learners, producing academically appropriate and impressive writing is further

complicated by limited linguistic exposure and insufficient opportunities for individualized feedback.

Learners are required to identify their weaknesses including wrong linguistic choices and bad textual quality, incoherence etc., for that purpose research in the field indicates that feedback with revision plays a determinative role in facilitating development of writing skills (Ferris, 2014; Hyland & Hyland, 2006). While the traditional classroom patterns present constraints for continuous and personalized feedback owing to time, class size and instructional resources, technology has long been employed to address these challenges. Research in Computer-Assisted Language Learning (CALL) has demonstrated that digital tools can enhance learner autonomy, increase engagement, and create opportunities for individualized language practice (Chapelle, 2003; Levy & Stockwell, 2006; Warschauer, 2000). Recent advances in generative AI have significantly expanded these possibilities. Unlike earlier writing-support technologies that primarily focused on grammar correction, tools such as ChatGPT can provide context-sensitive feedback on vocabulary, sentence structure, coherence, and organization while supporting multiple cycles of revision (Godwin-Jones, 2023; Barrot, 2023). Such capabilities have positioned AI as a potentially transformative resource in language education, capable of supporting learners throughout the writing process rather than merely evaluating final products.

Ongoing studies have reported encouraging outcomes associated with the use of ChatGPT in language learning contexts. Recent studies have reported that ChatGPT-assisted writing and AI-generated feedback can improve writing quality, learner engagement, and revision practices in second-language contexts (Barrot, 2023; Escalante, Pack, & Barrett, 2023; Yan, 2024). But at the same time, scholars have inclined towards more nuanced examination of the pedagogical mechanisms leading to these improvements (Kasneci et al., 2023; Holmes et al., 2022). Much of the existing literature focuses on learner perceptions or writing outcomes, while comparatively less attention has been devoted to understanding how AI-mediated feedback facilitates language development itself. Consequently, there remains a need for empirical studies

that move beyond effectiveness measures and examine the role of AI within established models of language learning.

It is very important to work on this gap because the educational value of AI does not lie merely in improving written texts but in supporting the processes through which learning occurs. When learners engage with AI-generated suggestions, revise their drafts, and reflect upon linguistic alternatives, they participate in a dynamic process of language development that assures closer examination. Understanding this is essential for determining how AI can be meaningfully integrated into language education and how it may complement existing pedagogical practices.

1.1 Research Questions

RQ1: How does ChatGPT-assisted revision influence the lexical diversity and readability in second-language academic writing?

RQ2: How can the observed patterns of revision be interpreted through Krashen's Input Hypothesis, Swain's Output Hypothesis, and Vygotsky's Sociocultural Theory?

RQ3: How do learners perceive the role of ChatGPT in facilitating second-language writing development?

2 Methodology

2.1 Theoretical Framework

This study is based on three foundational frameworks of Second Language Acquisition (SLA): Krashen's Input Hypothesis (1982), Swain's Output Hypothesis (1985), and Vygotsky's Sociocultural Theory (1978).

Krashen's Input Hypothesis posits that acquisition occurs when learners are exposed to *comprehensible input* slightly beyond their current proficiency level ($i+1$), facilitated by contextual and extra-linguistic support. In the present study, AI-generated revisions are examined as potential sources of such structured and adaptive input.

Swain’s Output Hypothesis emphasizes the role of *pushed output*, wherein learners develop linguistic competence by producing language that extends beyond their existing control. The revision process mediated by ChatGPT encourages learners to reprocess and refine their own output, thereby promoting syntactic and lexical development.

Vygotsky’s Sociocultural Theory introduces the concepts of the *Zone of Proximal Development (ZPD)* and the *More Knowledgeable Other (MKO)*. Within this framework, ChatGPT is conceptualized as a digital MKO, offering immediate, iterative, and scaffolded feedback that enables learners to perform beyond their independent linguistic capacity. This positions AI as an active mediational tool within the learner’s ZPD.

In this study, AI (ChatGPT) is conceptualized as a digital MKO that provides scaffolded input and feedback. These theories are operationalized as follows:

S. No	SLA Construct	Theoretical Source	Operational Indicator
1	Comprehensible input	Krashen (1982)	Observed through AI-generated revisions improving clarity and correctness.
2	Pushed output	Swain (1985)	Increased lexical diversity and syntactic complexity in revised drafts.
3	Scaffolding	Vygotsky (1978)	Progressive improvement between pre- and post-AI writing samples.

Table 1. Theoretical Framework

The study adopts a mixed-methods design, integrating computational textual analysis with qualitative interpretation, in alignment with CALL-based methodologies (Levy & Stockwell, 2006; Ellis, 2005).

2.2 Research Design and Procedure A structured three-stage experimental design was employed:

Stage 1: Pre-AI Writing Task

Participants produced an original text on the assigned topic under controlled conditions, without AI assistance. These texts served as baseline data.

Stage 2: AI-Assisted Revision

Participants revised their drafts using ChatGPT, guided by standardized prompts:

“Revise the following text to improve grammatical accuracy, coherence, vocabulary sophistication, and academic tone while preserving the original meaning and content. Suggest clearer sentence structures and more precise lexical choices where appropriate.”

The use of uniform prompts ensured consistency across participants. Revised texts were systematically paired with their original versions for subsequent analysis.

Stage 3: Reflection and Feedback

Participants shared short reflections on their experience of using ChatGPT during the revision process, focusing on perceived linguistic improvement, vocabulary enhancement, and the usefulness of AI-generated feedback. These reflections constituted the qualitative dataset for thematic analysis and were used to examine learners' perceptions of AI-assisted writing revision.

2.3 Quantitative Textual Analysis

Pre- and post-revision texts were analyzed using *Voyant Tools*, an open-source corpus analysis platform. The following linguistic features were examined:

- Vocabulary Density
- Word Frequency Distribution – to evaluate reliance on high-frequency vocabulary
- Readability Index – Voyant Tools generated readability scores that reflect the linguistic complexity of the text. Higher scores indicate that a text requires a higher educational reading level and therefore represents greater syntactic and lexical com-

plexity. In the present study, increases in readability scores are interpreted as evidence of enhanced academic sophistication and linguistic development rather than greater ease of reading.

2.4 Statistical Analysis

Descriptive statistics including mean, median, standard deviation, and range were calculated for vocabulary density and readability measures. To determine whether the observed differences between Draft 1 and Draft 2 were statistically significant, paired-samples t-tests were conducted. Statistical significance was evaluated at the 0.05 level.

2.5 Qualitative Analysis

Student reflection responses, and selected writing samples were analyzed using thematic analysis (Braun & Clarke, 2006). Initial codes were generated inductively from recurring patterns in learner responses and subsequently organized into themes related to lexical development, syntactic refinement, learner autonomy, and AI-mediated scaffolding. These themes were then interpreted through the lens of SLA theories.

2.6 Ethical Considerations

Participation in the study was voluntary. Students were informed about the purpose of the research, and all writing samples and reflection responses were anonymized prior to analysis. The study focused exclusively on academic writing performance and learner perceptions, ensuring confidentiality and ethical handling of participant data.

3 Corpus and Assignment

The study involved 64 second-year B.Tech students enrolled in a course on English for Professional Purposes at a state university in Uttar Pradesh, India. All participants were L2 learners of English, with proficiency levels ranging from lower-intermediate to upper-intermediate. Participants were assigned a content writing task on the topic: **“The Rise in Plant-Based Diets: Separating Fact from Fad.”**

The task was conducted in three phases:

- **Pre-writing phase (15 minutes):** Students engaged in guided reflection and were permitted to consult online resources to develop contextual understanding.
- **Writing phase (30 minutes):** Students produced an original draft under time constraints.
- **AI revision phase:** Students revised their drafts using ChatGPT.

All pre- and post-revision texts were collected and compiled into a structured corpus for analysis. The resulting corpus comprised 128 texts (64 Draft 1 and 64 Draft 2 submissions), providing a comparative dataset for pre- and post-intervention analysis.

4 Quantitative Analysis

To evaluate the impact of AI-assisted revision, readability scores and lexical features from Draft 1 (pre-intervention) and Draft 2 (post-intervention) were compared. *Table 2* presents a comparative analysis of key linguistic parameters, including vocabulary density, readability index, and average words per sentence. These metrics were extracted using Voyant Tools and subsequently analyzed to identify patterns of linguistic development.

The results indicate a consistent improvement in linguistic performance following ChatGPT-assisted revision. Vocabulary Density: 0.731 to 0.790, suggests greater lexical diversity in the revised drafts. Similarly, Readability Index scores increased from 8.76 to 10.43. Since higher readability scores in Voyant Tools correspond to higher educational reading levels, this increase suggests that the revised drafts exhibited greater lexical diversity, more developed sentence structures, and increased academic complexity. Changes in average words per sentence further suggest a tendency toward more elaborated sentence structures.

Figures 1 and 3 visually represent these patterns of change. The boxplot distributions reveal an upward shift in median scores for both vocabulary density and readability, accompanied by a reduction in lower-end scores. This pattern suggests that

improvements were observed not only among higher-performing students but across the cohort as a whole. The reduced dispersion of scores in the post-intervention texts further indicates greater consistency in writing performance following ChatGPT assisted revision.

To determine whether these observed improvements were statistically significant, paired-samples t-tests were conducted. The results confirmed significant differences between Draft 1 and Draft 2 for both vocabulary density and readability measures ($p < .05$), indicating that the gains were unlikely to have occurred by chance. These findings suggest that ChatGPT assisted revision contributed positively to lexical development and textual readability among the participants

Taken together, the quantitative results demonstrate that ChatGPT assisted revision was associated with measurable improvements in key indicators of writing quality. The observed gains in lexical diversity and readability provide empirical support for the potential of generative AI tools to facilitate second-language writing development.

S.No.	Name of student	Vocabulary Density: Draft 1	Draft 2	Readability Index: Draft 1	Draft 2	Average Words Per Sentence: Draft 1	Draft2	Most frequent words
Student 1	Anshu Kumari	0.649	0.816	9.494	11.672	17.1	98	<u>plant</u> (8);
Student 2	Deepti Gupta	0.782	0.803	11.471	11.483	22.3	49	<u>plant</u> (4);
Student 3	Anashva	0.767	0.773	11.562	10.746	57	70	<u>people</u> (4);
Student 4	Aditya Maheshwari	0.639	0.73	7.499	12.068	24.3	22.2	<u>people</u> (4);
Student 5	Anmol Agarwal	0.758	0.912	10.074	13.593	52.3	28.5	<u>diet</u> (3);

Student 6	Harshit Bhardwaj	0.717	0.8	8.426	7.896	60	21.7	<u>plant</u> (7);
Student 7	Abhay Verma	0.78	0.747	6.509	9.32	44	26.6	<u>plant</u> (4);
Student 8	Durgesh	0.793	0.884	12.543	12.704	36.3	36.5	<u>plant</u> (4);
Student 9	Arnav Pandey	0.806	0.84	8.455	9.045	46.3	48	<u>plant</u> (3);
Student 10	Ankit Pandey	0.836	0.832	10.961	10.732	23.3	23.8	<u>plant</u> (4);
Student 11	Anant Seth	0.736	0.706	9.563	10.248	30.6	26.7	<u>plant</u> (7);
Student 12	Ankit Saraswat	0.802	0.871	5.968	6.217	23.1	26.4	<u>plant</u> (4); thi
Student 13	Arya Pratap Singh	0.66	0.779	12.011	13.984	27	22.7	<u>diet</u> (9);
Student 14	Deepika Sisodia	0.674	0.697	7.369	13.338	23.4	22	<u>plant</u> (7);
Student 15	Anchal Singh	0.917	0.828	7.672	8.8	60	58	<u>diets</u> (2);
Student 16	Aparna Gautam	0.709	0.746	7.788	7.239	151	25.9	<u>based</u> (7);
Student 17	Krishna chandra	0.844	0.947	5.029	7.879	24.4	38	<u>plante</u> (2);
Student 18	Hemant Kumar	0.747	0.81	9.094	11.657	27.7	21	<u>based</u> (9);
Student 19	Abhay Gupta	0.672	0.784	7.609	9.506	21.1	21.8	<u>diet</u> (5);
Student 20	Abhishek Mishra	0.752	0.766	8.725	9.73	56.5	22.8	<u>plant</u> (4);
Student 21	Abhishek Mahajan	0.729	0.795	9.728	11.187	38.8	10.6	<u>based</u> (6);
Student 22	Anvesha Singh	0.595	0.678	6.074	9.437	27.2	19.2	<u>plant</u> (9);
Student 23	Astha Goswami	0.806	0.775	8.889	12.911	22.3	37.8	<u>plant</u> (4);

Student 24	Divyanshi kul-shreshtha	0.701	0.767	10.295	10.391	25.7	34.4	<u>based</u> (9);
Student 25	Abhishek Sharma	0.698	0.746	8.947	12.141	27.8	16.9	<u>diet</u> (5);
Student 26	Anjali Kumari	0.636	0.693	6.906	10.027	14.4	25.1	<u>plant</u> (6);
Student 27	Drishty Ahuja	0.902	0.781	9.11	11.484	112	53.3	<u>plant</u> (3);
Student 28	Abhay Pratap Singh	0.793	0.905	8.671	10.656	50	95	<u>based</u> (5);
Student 29	Chaitanya Jain	0.705	0.806	10.905	15.888	49.7	32.7	<u>diet</u> (6); <u>plant</u> (4); <u>veg</u> (3)
Student 30	Gargi Sharma	0.802	0.803	9.571	10.368	41.8	26.4	<u>foods</u> (3); <u>based</u> (3); <u>won't</u> (2);
Student 31	Aditya Mishra	0.641	0.786	9.479	9.92	72.5	24.2	<u>plant</u> (3); <u>will</u> (2); <u>trend</u> (2);
Student 32	Harendra Pratap Singh	0.705	0.918	10.474	11.248	17.3	110	<u>based</u> (8); <u>diet</u> (6); <u>plant</u> (5);
Student 33	Antariksh	0.653	0.688	8.332	7.77	36	29.7	<u>people</u> (5); <u>plants</u> (4); <u>just</u> (3);
Student 34	Aniket Goyal	0.736	0.773	11.099	11.264	32.6	20.7	<u>based</u> (8); <u>plant</u> (7);
Student 35	Aryan Kumar	0.741	0.803	6.928	7.049	29.4	33	<u>change</u> (3); <u>high</u> (2); <u>foods</u> (2);
Student 36	Ayush Pratap Singh	0.652	0.701	7.24	8.963	28.3	33.4	<u>based</u> (8); <u>diets</u> (7); <u>plant</u> (6);
Student	Ankit	0.699	0.766	7.826	9.289	76.5	29	<u>based</u>

37	Kumar Singh							(5); food (4); people (2);
Student 38	Anshul Sharma	0.64	0.656	8.705	8.645	23.4	19.7	based (10); plant (7); healthy (3);
Student 39	Arun Kumar	0.651	0.707	9.493	9.548	23.7	20	plant (9); based (8); diets (5);
Student 40	Anurag Yadav	0.713	0.676	6.278	6.782	35.8	34.8	people (5); plant (4); diets (4);
Student 41	Hansika	0.773	0.811	9.471	10.976	15.7	20.5	people (3); plant (2); heath (2);
Student 42	Kartikey Srivastava	0.866	0.866	10.152	10.152	17	17	vegan (4); people (3); health (2);
Student 43	Ayush Sahu	0.741	0.821	9.66	10.921	28.6	26.5	plant (7); based (7); diet (3);
Student 44	Anamika Rai	0.761	0.819	9.741	10.977	18.8	26.3	vegan (2); taking (2); suffi- cient (2); kind (2); flont (2)
Student 45	Harshita Garg	0.705	0.733	8.686	9.365	38.6	35.2	plant (8); based (7); vegan (2);
Student 46	Anupriya	0.725	0.725	7.902	7.902	38.3	38.3	plants (4); plant (4); fat
Student 47	Anushka singh	0.641	0.788	8.275	6.887	33	22	plant (6); diet (6); based (6);

Student 48	Kirtika Goel	0.71	0.863	12.03	17.435	23.3	47.5	<u>plant</u> (9); <u>based</u> (7); <u>food</u> (5);
Student 49	Dhruv Agrawal	0.744	0.794	11.336	7.881	23.8	34	<u>plant</u> (5); <u>based</u> (5); <u>diets</u> (3);
Student 50	Deeksha	0.72	0.8	5.395	8.699	31.1	17.2	<u>plant</u> (3); <u>just</u> (3); <u>time</u> (2)
Student 51	KirtiChaudhary	0.609	0.717	8.234	8.935	23	10.6	<u>diet</u> (7); <u>based</u> (6); <u>plant</u> (5);
Student 52	Dev Bhola	0.624	0.815	8.227	7.232	25	21.6	<u>plant</u> (5); <u>based</u> (5); <u>protein</u> (2);
Student 53	Ambika Mishra	0.74	0.868	12.644	12.212	104	36	<u>diet</u> (6); <u>plant</u> (5); <u>based</u> (4);
Student 54	Harsh Sharma	0.851	0.777	8.28	10.1	33.6	18.5	<u>people</u> (3); <u>wrong</u> (2); <u>they</u> (2);
Student 55	Chhavi Singhal	0.596	0.777	7.585	13.863	34	37	<u>plants</u> (9); <u>based</u> (5);
Student 56	Chirag Gupta	0.68	0.813	8.527	10.691	27.7	15.4	<u>diet</u> (6); <u>vegan</u> (5); <u>plant</u> (3);
Student 57	Durgesh Kumar Rawat	0.736	0.843	10.385	11.044	20	33.5	<u>plant</u> (7); <u>meat</u> (4); <u>use</u> (2);
Student 58	Ishendra Rai	0.685	0.695	9.236	12.819	47.7	41	<u>based</u> (4); <u>plant</u> (3); <u>good</u> (3);
Student 59	Abhishek Srivastava	0.742	0.796	7.521	10.412	50.3	137	<u>plant</u> (8); <u>meat</u> (3); <u>met</u> (2); <u>based</u> (2); <u>yous</u>

								(1)
Student 60	Kartik Changra	0.723	0.827	5.679	16.354	22.9	30	<u>people</u> (3); <u>it's</u> (3); <u>based</u> (3);
Student 61	Deep-anshu Rajput	0.933	0.853	5.777	9.122	30	23.8	<u>food</u> (2); <u>want</u> (1); <u>things</u> (1);
Student 62	He-mant Agarwal	0.716	0.853	6.972	11.633	15.7	27.2	<u>good</u> (6); <u>eating</u> (4); <u>diet</u> (4);
Student 63	Harsh-wardhan Singh	0.714	0.828	8.928	9.582	28	37.2	<u>plant</u> (4); <u>diet</u> (4); <u>based</u> (4);
Student 64	Dilip	0.788	0.788	7.113	9.715	26.4	16.5	<u>diet</u> (5); <u>based</u> (4); <u>plant</u> (3);

Table 2. A comparative Study of Vocabulary Density, Readability Index, and words per sentence

Y

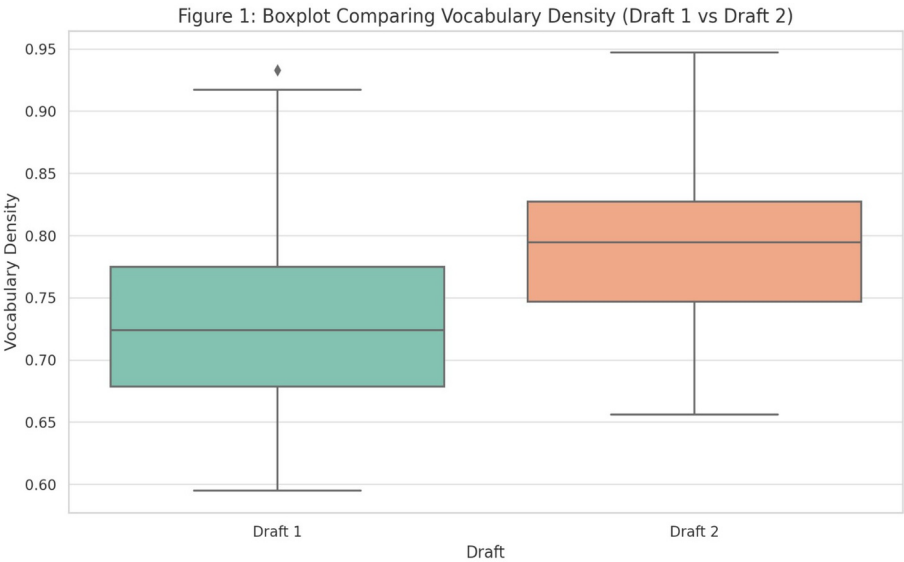


Fig. 1 Boxplot of Vocabulary Density 1

X

As shown in Figure 1, the vocabulary density is improved significantly after revision. Draft 2 has a higher median and a slightly narrower interquartile range that is indicative of overall improvement and enhanced consistency. Draft 1 shows more variability and some potential lower-end outliers. Most students scored higher in Draft 2, suggesting effective revision or feedback incorporation.

Metric	Draft 1	Draft 2
Mean	0.731	0.790
Median	0.724	0.795
Std Dev	0.075	0.064
Min	0.595	0.656
Max	0.933	0.947

Table 3. Summary Statistics: Vocabulary Density

The summary statistics for vocabulary density are presented in Table 3, which clearly illustrate the overall improvement from Draft 1 to Draft 2. There is a visible improvement in the performance of most of the students as Mean and median both increased from Draft 1 to Draft 2. Standard deviation decrease also suggests that students' performance became more consistent and less dispersed in draft 2. A statistical t-test to confirm if the improvement is significant is done and the result shows quite significant improvement in the performance. The result of t-test-

t-statistic: 6.86

p-value: 3.51×10^{-9} (very small) 0.000000003509415905

This p-value is far below the 0.05 threshold, meaning the improvement from Draft 1 to Draft 2 is statistically significant. The result of the paired-samples t-test revealed a statistically significant improvement in vocabulary density, $t(63) = 6.86, p < .001$. The effect size was large (Cohen's $d = 0.85$), indicating substantial practical significance. This finding suggests that the observed improvement was not only statistically significant but also educationally meaningful.

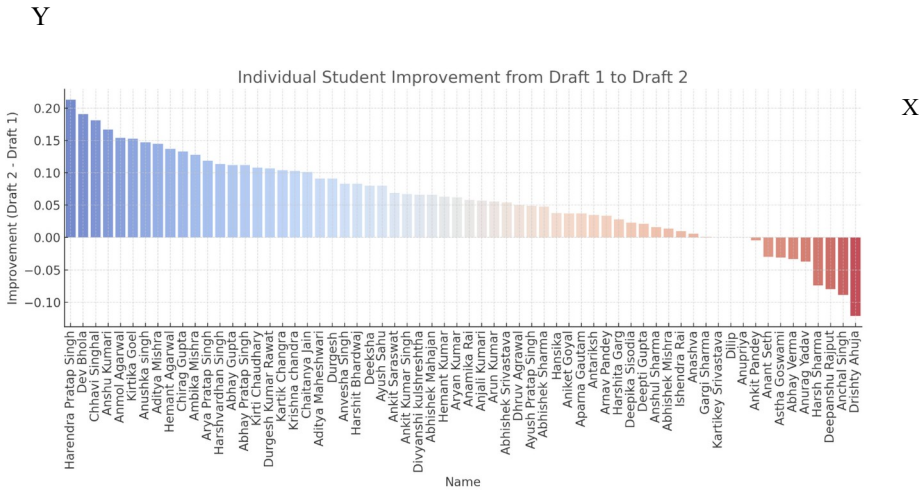


Fig. 2. Individual Improvement in Vocabulary

Figure 2 presents the individual improvement in vocabulary density between Draft 1 and Draft 2 for each of the 64 students. The improvement score was calculated as the difference between Draft 2 and Draft 1 scores. Students are ordered along the x-axis by the magnitude of their improvements and on Y-axis there is the difference in Vocabulary Density between Draft 2 and Draft 1 (i.e., improvement or decline). Positive values on the y-axis indicate an increase in vocabulary density from Draft 1 to Draft 2, while negative values reflect a decline. The leftmost bars (in deep blue) represent students who showed the most substantial improvements. For instance, Students Dev Bhola, and Chhavi Singhal displayed vocabulary density gains exceeding 0.18. The rightmost segment (in shades of red) includes students who experienced a decline in vocabulary density. Drishty Ahuja and Anchal Singh, for example, exhibited a decrease of more than 0.10. This visual not only highlights the variability in individual

performance but also demonstrates that a majority of students experienced measurable improvement, indicating the effectiveness of the intervention/tool (e.g., ChatGPT-assisted revision). The lowest score improved in Draft 2, showing that even the students with the least vocabulary density improved in their revised writing. The students not only revised but refined their lexical choices effectively.

Y

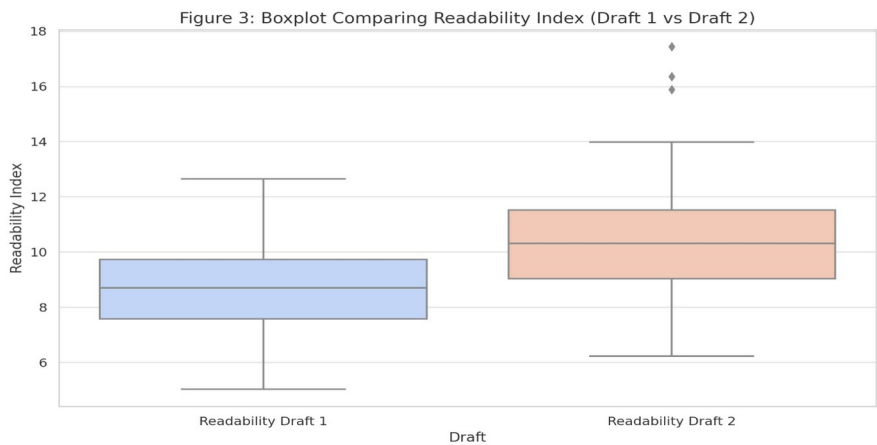


Fig. 3. Boxplot Readability Index 1

X

As illustrated in Figure 3, the median readability score increased substantially from Draft 1 to Draft 2, indicating an overall increase in the linguistic sophistication and academic complexity of students' revised texts. The upward shift in the median and quartile distribution suggests that the revised drafts exhibited greater textual clarity and more developed sentence structures.

A paired-samples t-test was conducted to evaluate the effect of ChatGPT-assisted revision on students' writing readability. The results indicated a statistically significant improvement in the readability index from Draft 1 ($M = 8.76$, $SD = 1.80$) to Draft 2 ($M = 10.43$, $SD = 2.28$), $t(63) = 6.10$, $p < .001$.

Metric	Draft 1	Draft 2
Mean	8.76	10.43
Standard Deviation	1.8	2.28
Minimum	5.03	6.22
25th Percentile (Q1)	7.57	9.02
Median (Q2)	8.7	10.31
75th Percentile (Q3)	9.73	11.52
Maximum	12.64	17.44

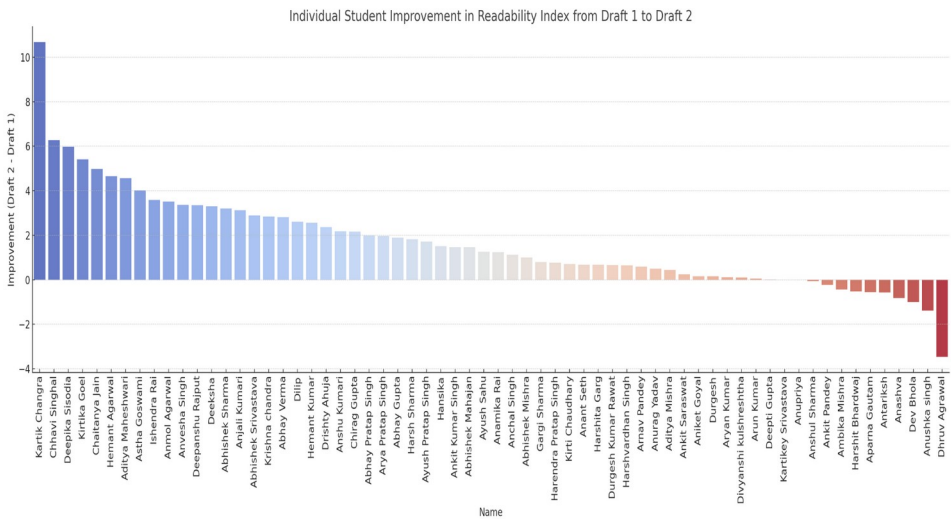
Table 4. Summary Statistics Readability Index

It should be noted that higher readability scores in the present analysis do not signify greater ease of reading. Rather, they indicate that the text requires a higher reading level, reflecting increased lexical and syntactic sophistication.

As shown in **Table 4**, the summary statistics for the readability index confirm that students’ revised drafts obtained higher Readability Index scores, indicating greater linguistic sophistication and more advanced sentence structures after the ChatGPT intervention. The increase in mean from 8.76 to 10.43 shows that there is a noticeable increase in the average readability index from Draft 1 to Draft 2. This indicates that the revised drafts exhibited greater textual complexity and linguistic sophistication, showing improvement in sentence structure, clarity, and fluency. The slightly higher standard deviation in Draft 2 suggests more variability in student performance in the revised drafts, some students made significant improvements while others showed moderate gains. Readability Index scores increased from 8.76 to 10.43. Since higher readability scores in Voyant Tools correspond to higher educational reading levels, this increase suggests that the revised drafts exhibited greater lexical diversity, more developed sentence structures, and increased academic complexity. The median value, representing the midpoint of the dataset, confirms that more than half the students improved significantly in writing clearer and more fluid prose. These gains reflect the effectiveness of the revision process and student engagement in enhancing sentence

structure, coherence, and language fluency. Thus, the statistical analysis confirms that there is significant improvement in the readability index with the intervention of ChatGPT.

Y



X

Fig. 4. Individual Improvement in Readability Index

Figure 4 visually presents the improvement in Readability Index scores for each of the 64 students, calculated as the difference between Draft 2 and Draft 1. The students are arranged along the x-axis based on the magnitude of their individual improvement, while the y-axis indicates the change in score. The left side of the graph (shaded in blue) shows students with positive improvement meaning their revised drafts became more readable while the right side (shaded in red) indicates a decline in readability. Notably, Kartik Changra, Chhavi Singhal, and Deepika Sisodia demonstrated the most significant improvements, with readability gains exceeding 6 points. These students likely adopted more effective sentence structures, transitions, and lexical choices. In contrast, a few students such as Dhruv Agrawal, Anushka Singh, and Dev Bhola

experienced a decline, suggesting possible over complication or deviation from clarity in their revisions. The overall distribution reveals that the majority of students benefitted from the revision process, reaffirming the effectiveness of ChatGPT-assisted drafting in enhancing syntactic clarity and fluency. The graphical gradient from blue to red clearly illustrates performance variability and underscores the importance of guided revision strategies.

A paired-samples t-test was conducted to compare the readability index scores before and after the ChatGPT intervention. The mean score increased from 8.76 (SD = 1.80) in Draft 1 to 10.43 (SD = 2.28) in Draft 2. The results revealed a statistically significant improvement t-statistic: 6.097, p-value: 7.26×10^{-8} , The effect size was large (Cohen's $d = 0.76$), indicating that the improvement in readability was practically meaningful in addition to being statistically significant. indicating that ChatGPT had a positive effect on students' writing. The p-value is much less than 0.05, indicating a statistically significant improvement in Readability Index from Draft 1 to Draft 2. This suggests that the revisions in Draft 2 have meaningfully enhanced the readability of students' writing.

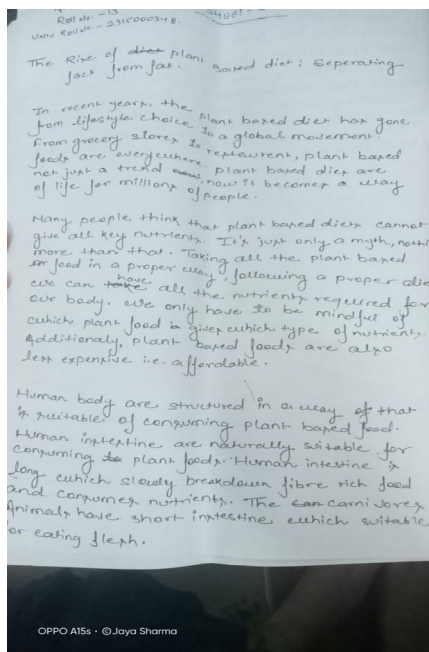
Consistent with the findings of Barrot (2023), the present study found that AI-assisted revision contributed to improvements in lexical diversity and overall writing quality. Similar observations have been reported by Yan (2024), who demonstrated that learners actively engaged with ChatGPT-generated feedback to improve their written output.

5 Qualitative Analysis of Writing Revisions and Student Reflections

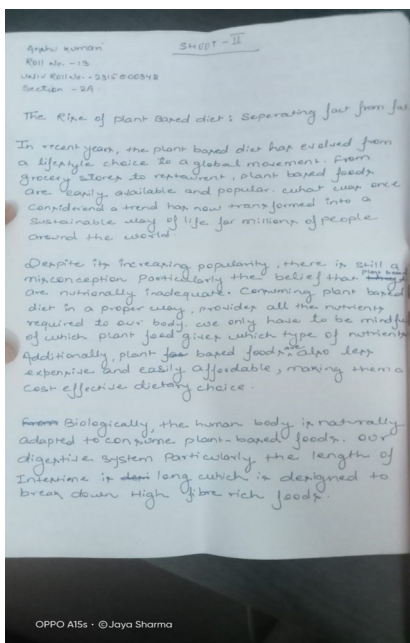
The qualitative analysis was based on a comparative examination of pre- and post-revision drafts and thematic analysis of student reflection responses. Analysis revealed three recurring themes: perceived improvement in writing quality, vocabulary enhancement, and AI-assisted scaffolding. Together, these themes provide insight into how learners experienced ChatGPT assisted revision and complement the quantitative findings.

5.1 Perceived Improvement in Writing Quality

Draft 1



Draft 2



Analysis of pre- and post-revision drafts revealed noticeable improvements in overall writing quality, particularly in terms of coherence, clarity, and organization of ideas. These improvements correspond with students' reflections, many of whom reported that their writing became more structured and effective after interacting with ChatGPT.

For instance, the student's original draft stated:

"Plant based diet has gone from lifestyle choice to a global movement. From grocery stores to restaurant, plant based foods are everywhere. Plant based diet are not just a trend now it becomes a way of life for millions of people."

Following AI-assisted revision, the same passage was reformulated as:

"The plant-based diet has evolved from a lifestyle choice to a global movement. From grocery stores to restaurants, plant-based foods are readily available and popular. What was once considered a trend has now transformed into a sustainable way of life for millions of people around the world."

The revised version shows greater coherence and logical flow of ideas. The original draft presents information as a sequence of loosely connected statements, the revised text establishes clearer relationships between ideas and develops a more persuasive introduction. The phrase *"what was once considered a trend has now transformed into a sustainable way of life"* provides a stronger argumentative focus and improves cohesion.

One other improvement that can be observed was in the development of supporting arguments. The revised draft demonstrates transitional expressions such as *"Despite its increasing popularity"* and elaborative statements such as *"making them a cost-effective dietary choice."* These additions enhance the flow of information and create a more structured discussion. The writing moves beyond simple description toward a more organized and academically appropriate presentation of ideas.

These findings suggest that ChatGPT assisted revision contributed not only to linguistic correction but also to improvements in discourse organization and overall communicative effectiveness. The enhanced coherence observed across the revised drafts supports students' perceptions that their writing became clearer, more professional, and easier to understand.

The transformation of the drafts from relatively fragmented and informal compositions to more coherent and academically organized texts reflects the scaffolded learning within the learner's Zone of Proximal Development (ZPD). In this sense, ChatGPT may be conceptualized as a digital MKO that mediated the writing process and enabled learners to achieve levels of performance beyond their unaided linguistic capacity (Vygotsky, 1978).

5.2 Vocabulary Enhancement and Language Awareness

Draft 1

The Rise of plant-based diets: Fact or Fad?
 In recent years, plant-based diets have gained tremendous popularity across the globe. From celebrities to everyday consumers, many are ditching meat and dairy in favour of fruits, vegetables, grains and legumes. But is this shift just a fleeting trend, or does it signal a permanent change in the way we eat?

Draft 2

1. Health-Driven Choices:-
 In recent years, plant-based diets have emerged as a global phenomenon, embraced by people from all walks of life. From health enthusiasts and environmentalists to celebrities and everyday individuals, the shift from meat and dairy to fruits, vegetables, grains and legumes has sparked widespread discussion. But is this movement just a temporary trend or does it signal a lasting transformation in the way we eat?

Revised drafts and the students' reflections clearly indicated vocabulary enhancement. Most of the students accepted that ChatGPT introduced more impressive alternative lexical choices and more formal expressions that improved the quality of their writing. They stated that *"I learned better words"* and *"the vocabulary became more professional"* suggesting that they have perceived noticeable improvement in lexical diversity following AI-assisted revision.

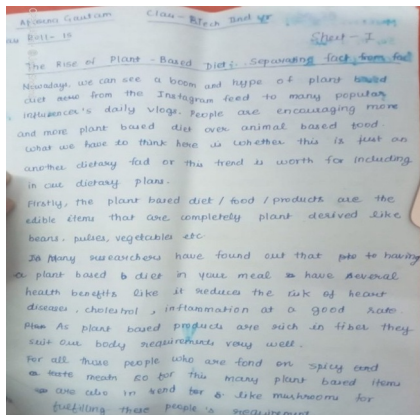
The writing samples when analysed supported these perceptions. For instance the above shown original draft one of one of the students described plant-based diets as having *"gained tremendous popularity across the globe."* In the revised version draft two this expression was reformulated as *"emerged as a global phenomenon, embraced by*

people from all walks of life." Similarly, the phrase "many are ditching meat and dairy" (draft 1) was replaced with "the shift from meat and dairy," (draft 2) creating a more formal and academically appropriate tone. Additional lexical enhancements included the introduction of expressions such as "health enthusiasts," "environmentalists," "widespread discussion," and "lasting transformation." These changes demonstrate increased lexical precision, variety, and contextual richness.

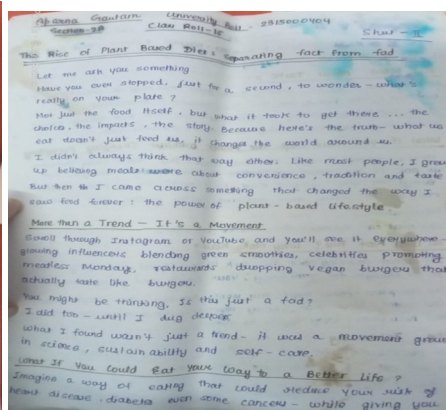
From Krashen's Input Hypothesis (1982), these revisions may be interpreted as instances of comprehensible input that facilitated lexical development and expanded learners' awareness of formal and academic language. ChatGPT exposed learners to vocabulary and phraseology beyond their present linguistic repertoire besides being comprehensible and contextually relevant.

5.3 Revision, Reflection, and Linguistic Development

Draft 1



Draft 2



Beyond lexical enhancement and improvements in writing quality, several revised drafts demonstrated substantial reformulation of ideas and discourse structure. These changes suggest that learners engaged in deeper reflection on how meaning could be communicated more effectively rather than merely correcting grammatical errors. For example, this student's original draft introduced the topic through a straightforward exposition:

"Nowadays, we can see a boom and hype of plant based diet also from the Instagram feed to many popular influencers daily vlogs. People are encouraging more and more plant based diet over animal based food."

Following ChatGPT-assisted revision, the introduction was transformed into a more engaging and rhetorically sophisticated passage:

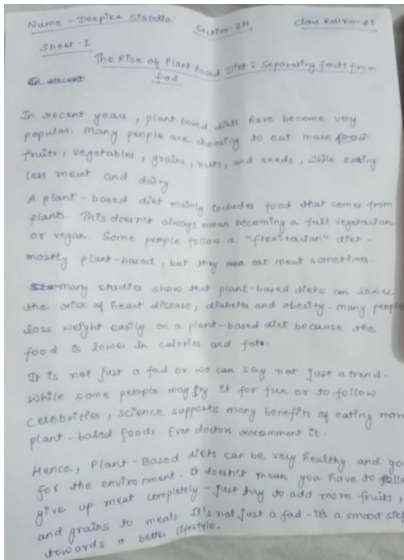
"Have you ever stopped, just for a second, to wonder what's really on your plate? Not just the food itself, but what it took to get there—the choices, the impacts, the story."

The revised version shows a significant shift in communicative approach. Rather than merely presenting information, the learner engages the reader directly through rhetorical questioning, adopts a persuasive voice, and structures ideas rhetorically to create interest and involvement. The revision also indicates the learner's ability to develop a narrative argument, moving beyond factual description to a more reflective discussion of food choices and their broader implications. Furthermore, the introduction of thematic subheadings such as *"More than a Trend -It's a Movement"* and *"What If You Could Eat Your Way to a Better Life?"* indicates an enhanced capacity to organize content into thematic sections, thereby improving coherence and reader navigation. These changes suggest a growing awareness of audience, purpose, and discourse organization key features of effective academic and persuasive writing.

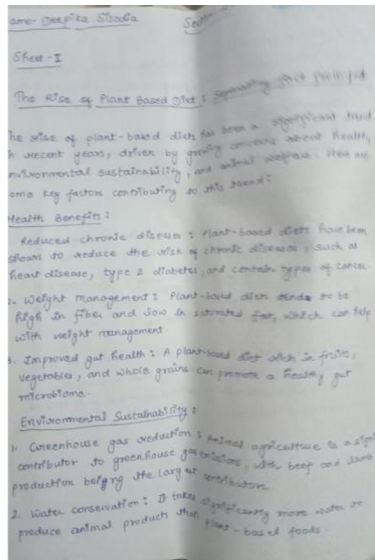
Such revisions indicate that the writing process involved active reformulation rather than passive correction. By reconsidering content, structure, and expression, learners were encouraged to produce more sophisticated linguistic output. This finding aligns with Swain's Output Hypothesis (1985), which argues that language development occurs when learners are pushed to modify, expand, and refine their language production. The evidence suggests that ChatGPT-assisted revision created opportunities for learners to engage in deeper linguistic processing, thereby facilitating both cognitive and linguistic development.

5.4 ChatGPT as a Digital Linguistic Scaffold

Draft 1



Draft 2



The combined evidence from writing samples and student reflections suggests that ChatGPT functioned as a digital linguistic scaffold throughout the writing task. Most participants reported that the AI-assisted revision process contributed positively to the quality of their writing and helped them communicate their ideas more effectively. Students frequently described the feedback as useful, informative, and supportive of their learning. One participant remarked that *"the suggestions are very useful,"* while another stated that *"I gained valuable insights."* Several students also acknowledged that ChatGPT enhanced their ability to express ideas with greater precision and clarity. As one student observed, *"ChatGPT gave the right words to express my emotions,"* indicating that the tool helped bridge lexical gaps and facilitated more effective communication.

The comparison of Draft 1 and Draft 2 further supports these perceptions. Revised texts consistently demonstrated improvements in grammatical accuracy, lexical diversity, coherence, and academic tone. Rather than replacing learners' original ideas. These findings may be interpreted through Vygotsky's (1978) concept of scaffolding. The

improvements observed in the revised drafts suggest that learners were able to perform beyond their independent linguistic capacity with the support of AI-generated feedback. In this sense, ChatGPT functioned as a digital More Knowledgeable Other (MKO), mediating learning within the learners' Zone of Proximal Development and facilitating higher levels of linguistic performance.

The findings also align with Krashen's Input Hypothesis (1982). Through exposure to richer vocabulary, more accurate grammatical constructions, and improved discourse structures, learners received comprehensible input that extended beyond their existing proficiency levels while remaining contextually meaningful. At the same time, the revision process reflects Swain's Output Hypothesis (1985), as students actively reformulated their drafts, reconsidered linguistic choices, and produced more sophisticated written output. Such engagement with language likely contributed to the significant gains observed in vocabulary density and readability.

Taken together, the evidence suggests that ChatGPT's contribution extended beyond simple error correction. By providing immediate, individualized, and context-sensitive feedback, the tool supported learners in refining their writing, expanding their linguistic repertoire, and developing greater confidence in academic communication. ChatGPT therefore emerges as an effective digital linguistic scaffold that facilitates second-language writing development within digitally mediated learning environments.

5.5 Synthesis of Finding

The qualitative findings, when considered alongside the quantitative results, provide a coherent picture of the role played by ChatGPT in supporting second-language writing development. Students consistently reported that the AI-assisted revision process improved the clarity, organization, and vocabulary of their writing. Reflections such as "*the suggestions are very useful*," "*I gained valuable insights*," and "*ChatGPT gave the right words to express my emotions*" indicate that learners perceived the tool as a meaningful source of linguistic support rather than merely an automated correction mechanism. Viewed through the lens of Second Language Acquisition theories, the

findings suggest that ChatGPT simultaneously functioned as a source of comprehensible input, a catalyst for pushed output, and a form of digital scaffolding. By exposing learners to richer linguistic alternatives, encouraging revision and reformulation, and providing immediate feedback, the tool supported learners in extending their linguistic capabilities beyond their initial level of performance. Collectively, the findings indicate that ChatGPT can serve as an effective digital linguistic scaffold that promotes language development, learner autonomy, and reflective engagement within AI-mediated learning environments.

6 Limitations of the study

The study has certain limitations. The sample was restricted to 64 engineering students from a single institution, limiting the generalizability of the findings. The intervention was conducted over a single writing task, making it difficult to assess long-term language development. Furthermore, the study focused primarily on vocabulary density and readability and did not examine syntactic complexity, cohesion, or discourse-level features. Future studies should incorporate longitudinal designs and broader linguistic measures to provide a more comprehensive understanding of AI-assisted writing development.

7 Conclusion

This study examined the pedagogical role of ChatGPT in second-language academic writing by framing AI-assisted revision through the theoretical lenses of Vygotsky's Sociocultural Theory, Krashen's Input Hypothesis, and Swain's Output Hypothesis. The findings reveal that ChatGPT-assisted revision resulted in measurably significant improvements in vocabulary density and readability, indicating measurable enhancement in lexical diversity, textual clarity, and overall writing quality.

The qualitative findings further revealed that learners perceived ChatGPT as a valuable source of linguistic support. Student reflections and textual comparisons showed evidence of vocabulary enrichment, improved discourse organization, and greater

awareness of audience and purpose. Rather than functioning merely as an error-correction tool, ChatGPT encouraged iterative revision and reflective engagement with language, thereby facilitating deeper linguistic processing.

The present study can be considered a meaningful contribution to the ongoing researches on AI-mediated language learning by exhibiting how generative AI can operationalize key principles of Second Language Acquisition from a theoretical perspective. ChatGPT provided learners with comprehensible linguistic input, encouraged the production of more sophisticated output, and functioned as a digital form of scaffolding within the learner's Zone of Proximal Development.

The study also contributes to current discussions on Digital Innovations and Educational Technology Ecosystems by illustrating how AI-powered feedback systems can support Outcome-Based Education through data-driven evaluation of learning outcomes. While AI cannot replace the pedagogical expertise of teachers, it can serve as a powerful supplementary resource that promotes learner autonomy, individualized feedback, and continuous revision.

Future research should employ longitudinal designs, larger and more diverse learner populations, and additional linguistic measures such as syntactic complexity, cohesion, and meta-discourse features to further explore the long-term educational implications of AI-assisted writing development.

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