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Evaluating the Impact of an AI-Powered Blended Learning Platform on Students' Business English Performance: A MANCOVA Approach

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Abstract

Background and Aim: The integration of artificial intelligence (AI) in education has significantly transformed language learning, particularly in blended learning environments. AI-powered platforms such as FLIT provide personalized learning experiences, real-time feedback, and data-driven insights, making them valuable tools for Business English instruction. However, factors such as gender and geographical background may influence student performance in these AI-driven environments. This study examines the impact of gender and geographical background on Business English proficiency (listening, speaking, reading, and writing) within an FLIT-based blended learning framework, and it explores the potential interaction between these factors.

Materials and Methods: Using a quasi-experimental design with pre-test and post-test assessments, 240 English major students from a science and technology university in northeastern China participated in ten weeks of FLIT-based instruction. Pre-tests and post-tests were administered using the Cambridge Business English Certificates (BEC) exam. Data were analyzed using ANCOVA to assess the main effects of gender and geographical background, and MANCOVA to investigate interaction effects.

Results: Results indicate that geographical background significantly influences Business English proficiency across all four language skills. For example, ANCOVA revealed that geographical background had a significant effect on reading performance ($F(3,232) = 17.31$, $p < 0.001$, partial $\eta^2 \approx 0.19$), with urban students scoring approximately 10% higher than their rural counterparts. In contrast, gender did not exhibit a statistically significant effect (all $p > 0.05$), and no interaction effect between gender and geographical background was observed.

Conclusion: The findings underscore the need to address regional disparities in AI-powered language learning environments. Practically, these results suggest that targeted interventions—such as enhanced digital literacy programs and increased allocation of educational resources to rural areas—are essential for bridging the performance gap. Policy-wise, investments in digital infrastructure and tailored educational technology are recommended to ensure equitable learning opportunities across diverse regions. Future research should investigate the long-term impacts of AI-powered instruction and consider additional learner variables such as motivation and learning styles.

Keywords: AI-powered Blended Learning; Business English Proficiency; Gender Differences; Geographical Background

Introduction

In recent years, the integration of artificial intelligence (AI) in education has transformed language learning by offering innovative, adaptive approaches that enhance learner engagement and performance. AI-powered platforms, such as FLIT, facilitate adaptive learning experiences by providing real-time feedback, personalized instruction, and data-driven insights into students' progress. These advancements have significantly influenced the teaching and acquisition of Business English, a specialized domain that requires proficiency in reading, writing, listening, and speaking within professional and corporate contexts (Chen et al., 2021; He & Yang, 2023). Nevertheless, the effectiveness of AI-driven blended learning in Business English remains underexplored, particularly in relation to individual learner characteristics such as gender and geographical background.

The Role of AI-Powered Learning in Business English Education

AI-enhanced educational platforms are revolutionizing blended learning models by combining traditional face-to-face instruction with intelligent digital tools (Hwang et al., 2020). These platforms employ machine learning algorithms, automated assessment systems, and intelligent tutoring mechanisms to provide tailored content and dynamic feedback (Wang & Han, 2022). In the context of Business English education, AI-powered platforms can personalize learning materials, assess performance in real time, and

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track progress through automated analytics, thereby optimizing language acquisition (Sun et al., 2020). The FLIT platform, utilized in this study, exemplifies an AI-integrated learning system that supports self-directed learning before and after class while enhancing interactive classroom activities.

Gender and Geographical Background in AI-Based Business English Learning

Two critical learner characteristics that may influence AI-powered Business English learning outcomes are gender and geographical background. Research on gender differences in language learning has produced mixed findings. Some studies suggest that female learners tend to excel in reading and writing, while male learners may perform better in listening and speaking tasks—differences that could be attributed to varying cognitive processes and learning preferences (Ellis, 2010; Vandergrift & Goh, 2012). Conversely, other studies indicate that when provided with personalized learning pathways via technology-enhanced instruction, gender disparities tend to diminish (Golonka et al., 2014). In parallel, geographical background plays a significant role in second language acquisition. Students from urban areas often have better access to high-quality English instruction, diverse learning resources, and environments conducive to real-world communication. In contrast, students from rural areas may face limitations in exposure to English and digital learning tools, potentially impacting their performance in AI-mediated learning environments (Chen & Liu, 2022). Despite these insights, few studies have specifically examined whether these factors interact or whether AI-based instruction can mitigate potential disparities.

Significance of the Study

This study addresses critical gaps in the literature by explicitly connecting these learner characteristics to Business English education within an AI-powered blended learning environment. Theoretically, it extends the understanding of how gender and geographical background affect language proficiency in a digitally mediated context, building on existing research in second language acquisition. Practically, the study provides valuable insights for educators and policymakers by identifying potential disparities in learning outcomes. Such insights are essential for informing more inclusive and adaptive AI-driven learning strategies, particularly in designing targeted interventions to support students from under-resourced regions.

Objectives

The primary objective of this study is to examine the effects of gender and geographical background on students' Business English proficiency within an FLIT-based blended learning environment. Specifically, the study aims to:

1. To evaluate the effect of gender on Business English performance across four core skills (listening, speaking, reading, and writing) in a blended learning environment.
2. To investigate the influence of students' geographical background on their Business English proficiency in listening, speaking, reading, and writing.
3. To assess the interaction between gender and geographical background and how this relationship affects Business English proficiency in the four language skills.

Literature review

Advancements in artificial intelligence (AI) have revolutionized language education, offering personalized, data-driven, and adaptive learning experiences. AI-powered teaching platforms are increasingly integrated into blended learning environments, enhancing students' performance in listening, reading, speaking, and writing (Zawacki-Richter et al., 2019). Business English, as a specialized domain of language education, requires proficiency in these four skills, often in professional and industry-specific contexts. This literature review explores the impact of AI-powered teaching platforms on language learning, with a particular focus on blended learning environments and Business English education. It examines studies that investigate the effects of AI-driven instruction on students' language competence and the role of blended learning in optimizing student outcomes.

AI-Powered Teaching Platforms in Language Education

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AI-powered teaching platforms leverage machine learning, natural language processing, and intelligent tutoring systems to provide personalized and interactive language learning experiences (Hwang et al., 2020). These platforms offer real-time feedback, adaptive learning pathways, and automated assessment, making them effective in addressing individual learning needs (Chen et al., 2022). AI-driven systems, such as FLIT, can track students' progress, identify weaknesses, and recommend tailored learning materials, leading to improved proficiency in language skills.

Several studies have demonstrated the effectiveness of AI-based platforms in language education. For example, Xu et al. (2021) found that an AI-powered learning system significantly enhanced students' listening and speaking skills by providing interactive and speech-recognition-based exercises. Similarly, Wang and Tahir (2020) reported that AI-driven personalized learning improved students' reading comprehension by adapting text difficulty levels to their proficiency. These findings highlight the potential of AI-powered instruction to support language acquisition by providing customized learning experiences.

AI in Blended Learning and Business English Education

Blended learning, which combines face-to-face instruction with online learning, has been widely adopted in Business English education (Graham, 2019). AI-powered platforms enhance blended learning by enabling self-directed study outside the classroom while providing instructors with data-driven insights into student progress (Rohmiyati, 2025). Studies indicate that AI-assisted blended learning fosters engagement, improves retention, and accommodates different learning paces, making it particularly effective for professional language training.

In Business English education, AI-driven tools support learners by offering real-world business scenarios, automated writing evaluation, and interactive simulations. Lin et al. (2020) found that AI-powered business communication simulations improved students' pragmatic competence and negotiation skills. Similarly, Tsai et al. (2022) observed that AI-integrated blended learning led to significant gains in Business English writing proficiency, particularly in structuring emails and reports. These findings suggest that AI-enhanced blended learning can bridge the gap between theoretical knowledge and practical business communication skills.

The Impact of AI-Powered Teaching Platforms on Language Skills

Listening comprehension is a critical component of Business English, requiring learners to process spoken information in real-time. AI-powered teaching platforms enhance listening skills by providing interactive exercises, speech recognition, and adaptive listening assessments (Lai & Zheng, 2022). AI-driven features such as automated subtitles, keyword extraction, and spoken dialogue practice help students develop their listening abilities in business contexts.

A study by Wang et al. (2021) found that AI-powered listening applications, which offer instant feedback on pronunciation and comprehension, significantly improved students' listening scores in Business English exams. Additionally, Nguyen and Shin (2023) demonstrated that AI-generated spoken dialogues, combined with real-time speech analysis, enhanced learners' ability to understand different accents and professional terminology in international business settings. These studies indicate that AI-powered instruction can support listening development by providing individualized learning pathways and real-time assessment.

AI-powered platforms improve reading comprehension by offering adaptive text difficulty, automated summarization, and interactive annotation tools (Cheng et al., 2020). These features help students engage with complex business texts, enhancing their ability to extract key information and interpret professional documents.

Research by Huang and Hong (2021) showed that AI-based reading analytics, which track students' reading speed and comprehension patterns, led to improved Business English reading performance. Similarly, He et al. (2022) found that AI-powered recommendation systems, which provide customized reading materials based on learners' proficiency, significantly enhanced reading retention and engagement. These studies highlight the effectiveness of AI in optimizing reading instruction by tailoring content to individual learning needs.

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Writing proficiency is essential in Business English, particularly for drafting professional emails, reports, and proposals. AI-powered platforms support writing development through automated feedback, grammar correction, and intelligent text generation (Bai & Wang, 2021). These features enable students to refine their writing skills by receiving instant, detailed feedback on linguistic accuracy, coherence, and style.

A study by Zhang et al. (2022) found that AI-based writing assistants significantly improved students' ability to structure business correspondence, reducing grammatical errors and enhancing clarity. Additionally, Yu and Xu (2023) reported that AI-powered peer review systems fostered collaborative learning, allowing students to improve their writing through structured feedback and revision cycles. These findings indicate that AI-driven writing tools can play a crucial role in developing business communication skills.

AI-powered speech recognition and pronunciation analysis tools enhance speaking proficiency by providing real-time feedback and interactive speaking exercises (Luo et al., 2020). Business English learners benefit from AI-driven simulations that allow them to practice workplace conversations, negotiations, and presentations.

Research by Kim et al. (2021) found that AI-powered virtual role-play exercises improved students' fluency and pronunciation accuracy. Similarly, Gao and Zhang (2022) demonstrated that AI-based speech evaluation tools helped learners develop confidence in public speaking and professional communication. These studies underscore the potential of AI-driven speaking instruction to enhance oral proficiency in business settings.

Interaction of Gender and Geographical Background in AI-Powered Learning

Gender and geographical background are critical factors influencing language learning outcomes. Studies suggest that AI-powered teaching platforms may mitigate gender disparities by providing equal access to personalized feedback and adaptive learning (Lee & Chen, 2020). However, some research indicates that male and female students may interact with AI-driven tools differently, with female students showing greater engagement in interactive language exercises (Vandergrift & Goh, 2012).

Geographical background also plays a role in students' access to and utilization of AI-powered learning. Sun et al. (2020) found that students from urban areas benefited more from AI-enhanced instruction due to greater digital literacy and internet accessibility. Conversely, rural students faced challenges related to technology adoption but demonstrated significant learning gains when provided with structured AI-driven support. These findings highlight the importance of considering demographic factors when implementing AI-powered language learning.

Conceptual Framework

This study examines the impact of gender and geographical background on students' Business English proficiency within an FLIT-based blended learning environment. The conceptual framework is structured around three primary research variables: gender, geographical background, and Business English performance across four core language skills (listening, speaking, reading, and writing). The study also investigates the interaction effect between gender and geographical background on Business English proficiency.

The two key independent variables in this study are gender and geographical background. Gender differences have long been a subject of inquiry in language learning, with some studies suggesting that female learners may demonstrate stronger language skills, particularly in reading and writing, while male learners may excel in speaking and listening (Ellis, 2010; Vandergrift & Goh, 2012). However, these differences are often influenced by instructional methods, learning environments, and individual cognitive preferences. Similarly, geographical background has been recognized as an important factor in second language acquisition, as students from different regions may have varying levels of educational access, exposure to English, and socio-economic influences that shape their proficiency (Sun et al., 2020).

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The dependent variables in this study are students' Business English performance across the four language skills:

Business English Listening Comprehension Ability (BELCA) – Evaluates students' ability to understand business-related audio materials, including short dialogues, note completion, and extended listening tasks.

Business English Speaking Skills (BESS) – Assesses students' spoken communication, including business-themed presentations, discussions, and interactive tasks.

Business English Reading Comprehension Ability (BERCA) – Measures students' ability to comprehend business-related texts, including multiple-choice questions, matching exercises, and cloze tests.

Business English Writing Skills (BEWS) – Examines students' ability to produce structured business correspondence, such as emails, reports, and written responses to business scenarios.

The conceptual model of this study illustrates the relationships between gender, geographical background, and Business English performance. The model hypothesizes direct effects of gender and geographical background on each language skill and interaction effects between gender and geographical background, as shown in Figure 1.

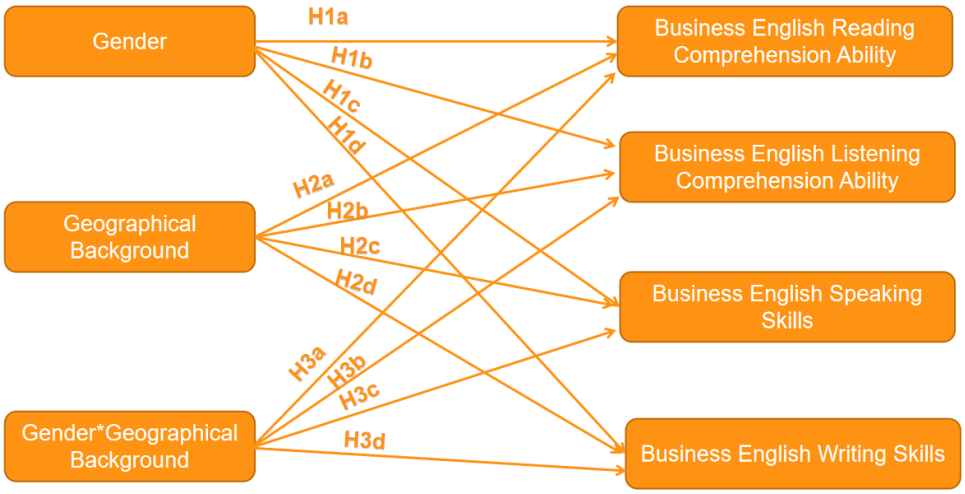

Figure 1 Conceptual Framework of the Study

Based on these independent and dependent variables, the study formulates the following hypotheses:

H1a: Gender has a statistically significant impact on students' performance in Business English listening

H1b: Gender has a statistically significant impact on students' performance in Business English speaking

H1c: Gender has a statistically significant impact on students' performance in Business English reading.

H1d: Gender has a statistically significant impact on students' performance in Business English writing.

H2a: Students' geographical background significantly influences their performance in Business English listening.

H2b: Students' geographical background significantly influences their performance in Business English speaking.

H2c: Students' geographical background significantly influences their performance in Business English reading.

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H2d: Students' geographical background significantly influences their performance in Business English writing.

H3a: There is a statistically significant interaction between gender and geographical background affecting students' Business English listening.

H3b: There is a statistically significant interaction between gender and geographical background affecting students' Business English reading.

H3c: There is a statistically significant interaction between gender and geographical background affecting students' Business English writing.

H3d: There is a statistically significant interaction between gender and geographical background affecting students' Business English speaking.

Methodology

This study adopts a quasi-experimental research design to examine the impact of gender and geographical background on students' Business English performance in a blended learning environment using the FLIT platform. The design is appropriate because participants are assigned to pre-existing groups rather than being randomly selected, allowing the investigation of real-world classroom dynamics while maintaining experimental control (Creswell & Creswell, 2018). The study's primary aim—comparing pre-test and post-test results to measure the effectiveness of FLIT-based instruction—is directly aligned with its objectives and hypotheses regarding the influence of gender, geographical background, and their interaction on Business English proficiency.

Population and Sample

The target population comprises 700 English major students enrolled in a Business English course at a science and technology university in northeastern China. As members of Generation Z, these students are technologically proficient and favor multimedia-rich, interactive, and data-driven educational experiences (Cilliers, 2017). A purposive sampling technique was used to select a representative sample of 240 students based on criteria such as English proficiency, class size, and College Entrance Examination scores (Ilker et al., 2016). The sample was distributed evenly across four existing classes using a zigzag sampling method to ensure comparable average levels of Business English proficiency, thus preserving the study's validity and reliability.

Research Instruments

Students' Business English proficiency was assessed using a pre-test and post-test framework based on the Cambridge Business English Certificates (BEC) exam—a globally recognized standard for business English (Laza, 2001). The exam evaluates proficiency in reading, listening, writing, and speaking through a variety of tasks, including multiple-choice questions, matching, cloze exercises, note completion tasks, business correspondence writing, and interactive speaking activities. The assessment instruments have been used at the university for five years and adhere to ISO 9001 standards and the ALTE quality framework, ensuring high reliability and validity.

Data Collection

Data collection spanned ten weeks and was structured into three phases:

Preparation and Pre-Test Administration (Week 1): A pre-test was conducted as a mid-term exam to assess baseline proficiency. This phase also involved orienting students to the research process and the FLIT platform.

FLIT-Based Blended Learning (Weeks 2–9): Students engaged in Business English instruction for two 1.5-hour classes per week. All classes were taught by the same instructor using identical materials and followed Gagné's Nine Events of Instruction to ensure a structured and interactive learning experience. The FLIT platform supported self-directed learning, interactive classroom activities, and provided real-time, AI-driven feedback. (Gagné. 2005).

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Post-Test Administration (Week 10): A final exam was administered to measure learning gains. Data from both tests, along with information recorded by the FLIT platform on student engagement and progress, were collected for analysis.

Statistical Analysis

Data analysis was performed using Jamovi 2.6.24. Descriptive statistics (mean scores, standard deviations, and performance trends) provided an overview of the data. ANCOVA was employed to examine the main effects of gender and geographical background on Business English performance, aligning with the study's objectives and hypotheses by controlling for pre-test scores. Additionally, MANCOVA was used to assess the interaction effects between gender and geographical background on the multiple language skills outcomes. These statistical analyses were selected to explicitly test the research hypotheses regarding whether gender and geographical background—and their interaction—significantly influence improvements in Business English proficiency following the FLIT-based intervention.

Ethical compliance was ensured through strict adherence to guidelines, including informed consent, confidentiality, anonymity, and the right to withdraw without penalty. The study received institutional approval from the university's ethics committee, further confirming adherence to research ethics standards.

Results

Demographic information

The demographic profile of the sample, as shown in Table 1, reveals that female participants (159, 66.3%) outnumber male participants (81, 33.8%). This gender distribution reflects common trends in Business English learning environments, where female students often constitute a larger proportion of language learners (Vandergrift & Goh, 2012).

Regarding geographical background, the largest proportion of students (144, 60%) comes from Region 4 (Northeastern Region: Jilin, Heilongjiang, and Liaoning). This region, known for its heavy industry and economic restructuring, has the highest representation, which may indicate an increasing emphasis on Business English education to support economic transitions.

Region 2 (Central Region: Shanxi, Jiangxi, Anhui, Hubei, Henan, and Hunan) accounts for 48 students (20%), representing a moderate level of participation. This region, characterized by steady economic growth, may exhibit a rising demand for Business English due to expanding trade and business opportunities.

Region 1 (Eastern Region: Beijing, Hebei, Tianjin, Shanghai, Jiangsu, Fujian, Zhejiang, Guangdong, Shandong, and Hainan) and Region 3 (Western Region: Inner Mongolia, Chongqing, Guangxi, Sichuan, Yunnan, Guizhou, Tibet, Shaanxi, Qinghai, Gansu, Ningxia, and Xinjiang) each comprise 24 students (10%). The relatively lower representation of Region 1, despite being the most developed economic area, may stem from a well-established English education system, reducing students' need for supplementary language training. Conversely, the Western Region, characterized by a mix of economic disparities and a dense population, may have lower participation due to differences in educational access.

Overall, the sample represents a diverse geographical distribution, allowing for an in-depth exploration of the effects of gender and regional background on Business English performance in an AI-enhanced learning environment.

Table 1 Demographic Information of Sample

		Counts	% of Total	Cumulative %
Gender	female	159	66.30%	66.30%
	male	81	33.80%	100.00%
Area	1	24	10.00%	10.00%
	2	48	20.00%	30.00%
	3	24	10.00%	40.00%

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	Counts	% of Total	Cumulative %
4	144	60.00%	100.00%

Descriptive Statistics Analysis

The descriptive statistics provide an overview of Business English performance in relation to gender and geographical background among students exposed to FLIT-based blended learning.

Table 2 presents the descriptive statistics for Business English performance across four key language skills—reading, listening, writing, and speaking—disaggregated by gender. The results reveal minimal differences between male and female students, suggesting a largely comparable level of proficiency in Business English.

In pre-test scores (PT), male and female students demonstrated similar levels of performance across all assessed skills. For instance, PT-Reading scores were nearly identical, with females scoring 32.55 (SD = 5.02) and males scoring 32.52 (SD = 4.73). Likewise, in PT-Listening, both groups exhibited comparable means (23.92 for females vs. 24.23 for males, SD = 3.67 for both). However, in PT-Writing and PT-Speaking, males displayed slightly higher mean scores (4.06 vs. 3.89 in writing; 10.42 vs. 9.91 in speaking), indicating a marginal advantage in productive language skills.

In post-test scores (PO), male students consistently outperformed female students, though the differences remained modest. In PO-Reading, male students scored 35.48 (SD = 5.03), slightly exceeding the female mean of 34.68 (SD = 4.71). A similar pattern was observed in PO-Listening (26.05 vs. 25.59), PO-Writing (6.37 vs. 5.84), and PO-Speaking (12.17 vs. 11.86). These differences, while small, suggest that male students may have experienced slightly greater performance gains.

When examining total scores, males exhibited marginally higher overall performance in both pre-test and post-test measures. PT-Total scores were 71.23 for males and 70.26 for females, while PO-Total scores reached 80.07 for males and 77.97 for females. The standard deviations indicate that male students exhibited slightly greater variability in their post-test performance across the four skill areas.

Table 2 Descriptive Statistics of Business English Performance by Gender

	Gender	N	Mean	SD	Minimum	Maximum
PT-Reading（45）	female	159	32.55	5.02	19	45
	male	81	32.52	4.73	20	40
PT-Listening（30）	female	159	23.92	3.67	14	30
	male	81	24.23	3.67	12	30
PT-Writing（10）	female	159	3.89	1.86	1	8
	male	81	4.06	1.96	1	9
PT-Speaking（15）	female	159	9.91	2.81	4	15
	male	81	10.42	3.03	3	15
PO-Reading（45）	female	159	34.68	4.71	21	45
	male	81	35.48	5.03	26	45
PO-Listening（30）	female	159	25.59	3.29	17	30
	male	81	26.05	3.46	16	30
PO-Writing（10）	female	159	5.84	1.72	2	10
	male	81	6.37	1.99	2	10
PO-Speaking（15）	female	159	11.86	2.15	6	15
	male	81	12.17	2.54	4	15
PT-Total（100）	female	159	70.26	6.57	52	86
	male	81	71.23	6.74	53	83

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	Gender	N	Mean	SD	Minimum	Maximum
PO-Total（100）	female	159	77.97	8.68	50	98
	male	81	80.07	9.91	57	100

Table 3 presents the descriptive statistics of Business English performance across four geographical regions in China, measured in reading, listening, writing, and speaking skills before (PT) and after (PO) instruction. The findings indicate regional differences in students' performance, with notable variations in both pre-test and post-test scores across all skills.

In PT-Reading, students from Region 4 (Northeastern Region) had the highest mean score (32.81, SD = 4.91), followed closely by students from Region 2 (Central Region, M = 32.65, SD = 4.8) and Region 3 (Western Region, M = 32.46, SD = 4.77). In contrast, students from Region 1 (Eastern Region) had the lowest reading scores (M = 30.79, SD = 5.26).

For PT-Listening, students from Region 1 outperformed other regions (M = 24.75, SD = 3.50), while students from Region 3 had the lowest mean (M = 23.5, SD = 3.43). Similarly, in PT-Speaking, Region 4 had the highest mean (M = 10.40, SD = 2.92), while Region 3 lagged behind with the lowest mean score (M = 8.96, SD = 2.91). The differences in pre-test scores suggest potential regional disparities in language preparation and prior exposure to Business English.

In the post-test (PO) phase, regional disparities persisted, particularly in reading and speaking performance. Region 1 students demonstrated the highest post-test reading scores (M = 39.75, SD = 3.29), surpassing all other regions. Conversely, students from Region 3 exhibited the lowest PO-Reading performance (M = 31.88, SD = 4.26).

For PO-Listening, students from Region 1 again led with the highest mean (M = 27.38, SD = 2.53), while students from Region 3 remained the lowest (M = 24.63, SD = 3.41). A similar trend was observed in PO-Writing, where Region 1 students outperformed others (M = 7.67, SD = 1.63), while Region 3 had the lowest scores (M = 4.54, SD = 1.84), suggesting a stronger writing ability among students from the Eastern region.

In PO-Speaking, Region 2 students performed best (M = 12.81, SD = 2.35), followed closely by Region 1 (M = 12.79, SD = 2.00). Meanwhile, Region 3 had the lowest PO-Speaking scores (M = 9.54, SD = 1.61). This suggests a potential gap in spoken English proficiency among students from the Western region.

Examining total pre-test (PT-Total) and post-test (PO-Total) scores, students from Region 4 achieved the highest PT-Total mean (M = 71.16, SD = 6.48), while Region 1 scored the lowest (M = 68.92, SD = 6.52). However, post-test scores showed a shift, with Region 1 achieving the highest PO-Total score (M = 87.58, SD = 6.19), significantly outperforming Region 3 (M = 70.58, SD = 8.10). This suggests that students from Region 1 benefited the most from the AI-driven learning platform, experiencing the largest performance gains.

These findings highlight significant regional differences in Business English proficiency, both before and after instruction. The Eastern region (Region 1) consistently showed the highest post-test performance, suggesting that students from this economically developed area may have had greater access to high-quality English education and learning resources. In contrast, students from the Western region (Region 3) displayed the lowest post-test performance, indicating potential challenges in language acquisition and educational disparities.

The results suggest that geographical background plays a crucial role in Business English performance, which may be attributed to differences in regional economic development, educational resources, and access to English learning opportunities.

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Table 3 Descriptive Statistics of Business English Performance by Geographical Region

	Area	N	Mean	SD	Minimum	Maximum
PT-Reading （45）	1	24	30.79	5.26	20	39
	2	48	32.65	4.8	20	45
	3	24	32.46	4.77	24	39
	4	144	32.81	4.91	19	44
PT-Listening （30）	1	24	24.75	3.5	15	30
	2	48	23.96	3.45	17	30
	3	24	23.5	3.43	16	30
	4	144	24.01	3.81	12	30
PT-Writing （10）	1	24	3.96	1.6	1	8
	2	48	3.96	1.68	1	7
	3	24	3.92	2.3	1	8
	4	144	3.94	1.95	1	9
PT-Speaking （15）	1	24	9.42	2.81	5	15
	2	48	10.02	2.71	5	15
	3	24	8.96	2.91	4	15
	4	144	10.4	2.92	3	15
PO-Reading （45）	1	24	39.75	3.29	34	45
	2	48	34.98	4.45	27	45
	3	24	31.88	4.26	26	39
	4	144	34.65	4.71	21	45
PO-Listening （30）	1	24	27.38	2.53	23	30
	2	48	26.29	3.52	16	30
	3	24	24.63	3.41	18	30
	4	144	25.48	3.3	17	30
PO-Writing （10）	1	24	7.67	1.63	5	10
	2	48	7.19	1.75	4	10
	3	24	4.54	1.84	2	9
	4	144	5.6	1.47	2	10
PO-Speaking （15）	1	24	12.79	2	9	15
	2	48	12.81	2.35	7	15
	3	24	9.54	1.61	5	12
	4	144	11.94	2.13	4	15
PT-Total （100）	1	24	68.92	6.52	52	81
	2	48	70.58	7.06	54	81
	3	24	68.83	6.62	54	82
	4	144	71.16	6.48	52	86
PO-Total （100）	1	24	87.58	6.19	80	100
	2	48	81.27	9.45	61	95

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	Area	N	Mean	SD	Minimum	Maximum
	3	24	70.58	8.1	57	85
	4	144	77.68	8.14	50	98

In simpler terms, while male and female students start at about the same level, males tend to make slightly larger gains after instruction. Also, students' performance varies by region, with those from certain regions (especially the Eastern region) showing more improvement, likely due to better educational resources and opportunities.

Hypotheses Testing of H1 and H2

Normality Test

The normality of the Business English post-test scores across four language skills (reading, listening, writing, and speaking), as well as the total scores, was assessed using skewness and kurtosis values. According to Hair et al. (2010), a variable is considered to have an approximately normal distribution if its skewness values fall between -2 and +2 and kurtosis values range from -7 to +7.

Table 4 Normality Test of Business English Post-Test Scores by Gender

					Skewness		**Kurtosis**	
	Gender	**N**	**Mean**	**SD**	**Skewness**	**SE**	**Kurtosis**	**SE**
PO-Reading（45）	female	159	34.68	4.71	0.0238	0.192	-0.2469	0.383
	male	81	35.48	5.03	-0.0319	0.267	-0.6327	0.529
PO-Listening（30）	female	159	25.59	3.29	-0.4833	0.192	-0.4741	0.383
	male	81	26.05	3.46	-0.7205	0.267	-0.0115	0.529
PO-Writing（10）	female	159	5.84	1.72	0.3682	0.192	-0.3607	0.383
	male	81	6.37	1.99	-0.0426	0.267	-0.2851	0.529
PO-Speaking（15）	female	159	11.86	2.15	-0.2271	0.192	-0.7013	0.383
	male	81	12.17	2.54	-0.7545	0.267	0.5012	0.529
PO-Total（100）	female	159	77.97	8.68	-0.0883	0.192	-0.1271	0.383
	male	81	80.07	9.91	-0.2071	0.267	-0.6277	0.529

The skewness values for female students ranged from -0.48 (Listening) to 0.37 (Writing), while for male students, the values ranged from -0.75 (Speaking) to -0.03 (Reading). These values indicate no severe deviations from normality. The kurtosis values also fall within the acceptable range, with the highest at 0.50 (Speaking for males) and the lowest at -0.70 (Speaking for females). Since all skewness and kurtosis values are within the recommended thresholds, the data distribution for both gender groups can be considered normal, meeting the assumption for ANCOVA.

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Table 5 Normality Test of Business English Post-Test Scores by Geographical Region

					Skewness		Kurtosis	
	Area	**N**	**Mean**	**SD**	**Skewness**	**SE**	**Kurtosis**	**SE**
PO-Reading （45）	1	24	39.75	3.29	0.12922	0.472	-1.037	0.918
	2	48	34.98	4.45	0.21149	0.343	-0.367	0.674
	3	24	31.88	4.26	0.38223	0.472	-1.107	0.918
	4	144	34.65	4.71	-0.00184	0.202	-0.122	0.401
PO-Listening （30）	1	24	27.38	2.53	-0.25185	0.472	-1.61	0.918
	2	48	26.29	3.52	-0.93699	0.343	0.24	0.674
	3	24	24.63	3.41	-0.23022	0.472	-0.429	0.918
	4	144	25.48	3.3	-0.47376	0.202	-0.433	0.401
PO-Writing （10）	1	24	7.67	1.63	0.19848	0.472	-0.965	0.918
	2	48	7.19	1.75	-0.27491	0.343	-0.871	0.674
	3	24	4.54	1.84	1.02233	0.472	1.117	0.918
	4	144	5.6	1.47	0.21536	0.202	0.187	0.401
PO-Speaking （15）	1	24	12.79	2	-0.29254	0.472	-1.259	0.918
	2	48	12.81	2.35	-0.64898	0.343	-0.843	0.674
	3	24	9.54	1.61	-1.12966	0.472	1.422	0.918
	4	144	11.94	2.13	-0.60037	0.202	0.528	0.401
PO-Total （100）	1	24	87.58	6.19	0.65132	0.472	-0.54	0.918
	2	48	81.27	9.45	-0.53791	0.343	-0.811	0.674
	3	24	70.58	8.1	0.29384	0.472	-1.012	0.918
	4	144	77.68	8.14	0.01021	0.202	0.329	0.401

The skewness values across the four geographical regions ranged from -1.12 (Speaking, Region 3) to 1.02 (Writing, Region 3), with most values falling close to zero, suggesting a fairly symmetric distribution. The kurtosis values ranged from -1.61 (Listening, Region 1) to 1.42 (Speaking, Region 3), with no extreme deviations beyond the acceptable limits. These results confirm that the data for Business English post-test scores are normally distributed across geographical backgrounds, satisfying the assumption required for ANCOVA.

Homogeneity Test

Levene's test was conducted to examine the assumption of homogeneity of variance across groups for post-test scores in Reading, Listening, Writing, Speaking, and the Total Score. The test results indicate that the p-values for all skills exceed the significance threshold of 0.05, suggesting that the assumption of equal variance holds across groups (Field, 2018; Pallant, 2020).

Table 6 shows that the p-values for Reading ($p = 0.654$), Listening ($p = 0.603$), Writing ($p = 0.482$), Speaking ($p = 0.104$), and Total Score ($p = 0.43$) all indicate non-significant results, confirming that the variability of scores does not differ significantly between groups. Since the assumption of homogeneity of variance is met, it is appropriate to proceed with ANCOVA for hypothesis testing without concerns about variance inequality affecting the results.

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Table 6 Homogeneity Test of Variables

Skills	F	df1	df2	p
Reading	0.721	7	232	0.654
Listening	0.782	7	232	0.603
Writing	0.932	7	232	0.482
Speaking	1.72	7	232	0.104
Total	1	7	232	0.43

Linearity and Homogeneity of Regression Slopes Check

Before conducting ANCOVA and MANCOVA analyses, it is essential to ensure that the fundamental statistical assumptions are met to guarantee valid results. Two key assumptions in this context are linearity and homogeneity of regression slopes (Field, 2018; Tabachnick & Fidell, 2019).

Linearity refers to the assumption that the relationship between the independent variable(s) and the dependent variable is best described by a straight-line function. A violation of linearity may lead to biased parameter estimates and misinterpretation of results (Pallant, 2020). In this study, scatterplots were used to visually inspect the linearity between pre-test and post-test scores across different groups, with regression lines overlaid to assess the trend of relationships (Hair et al., 2010). If the scatterplot displays a clear linear trend, the assumption of linearity is upheld.

Homogeneity of regression slopes is a crucial assumption for ANCOVA, ensuring that the relationship between the covariate (pre-test scores) and the dependent variable (post-test scores) is consistent across different levels of the independent variable(s). If interaction effects exist between the covariate and the independent variable, it suggests that the influence of the covariate varies between groups, violating this assumption (Field, 2018). This was examined by visually inspecting the parallelism of regression lines in scatterplots; if the slopes are approximately equal across groups, the assumption is considered satisfied (Tabachnick & Fidell, 2019).

This section provides a detailed examination of linearity and homogeneity of regression slopes for each language skill (reading, listening, writing, speaking) and the overall performance, categorized by geographical region and gender.

As is shown in Figure 2, the scatterplot for reading performance across four geographical regions (Areas 1–4) reveals a linear relationship between pre-test and post-test scores, supporting the assumption of linearity. The regression lines for the different regions appear mostly parallel, indicating that the relationship between pre-test and post-test reading scores remains consistent across different geographical backgrounds. The boxplots and density plots suggest minor differences in score distributions, but these do not significantly impact the overall trend. The assumptions of linearity and homogeneity of regression slopes hold for reading performance across geographical regions.

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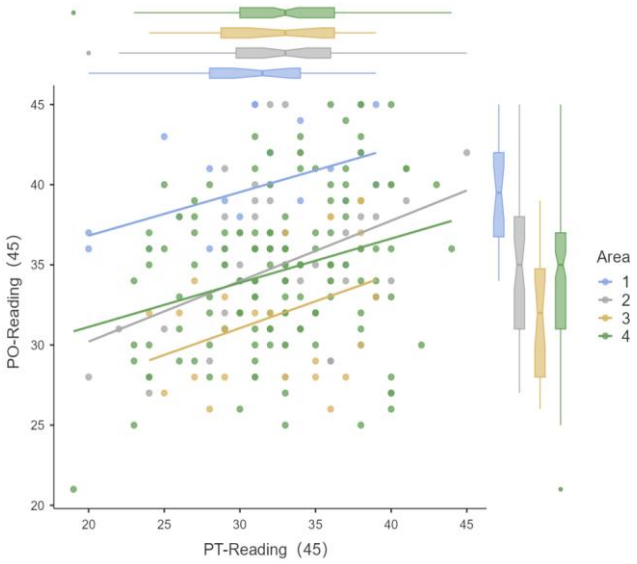

Figure 2 Scatterplot of Pre-test and Post-test Reading Scores Across Geographical Regions

For the listening performance in Figure 3, a positive linear trend is observed, though some variation in slopes is present among the regions. Area 3 exhibits a slightly different slope, but the overall pattern remains consistent. While this minor divergence could be explored further, it does not indicate a significant violation of the homogeneity assumption. The assumptions of linearity and homogeneity of regression slopes are satisfied, though slight slope variations exist.

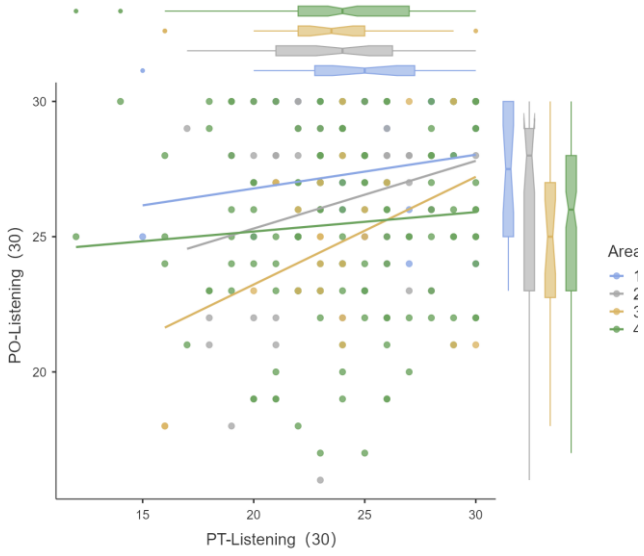

Figure 3 Scatterplot of Pre-test and Post-test Listening Scores Across Geographical Regions

The writing performance scatterplot in Figure 4 exhibits strong linearity, as indicated by the upward trend in all four regions. The regression slopes are largely parallel, confirming homogeneity of regression slopes. However, Area 3 has a notably lower slope compared to the others, which may suggest regional

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differences in writing development. The assumptions of linearity and homogeneity of regression slopes hold, with a minor slope deviation in Area 3.

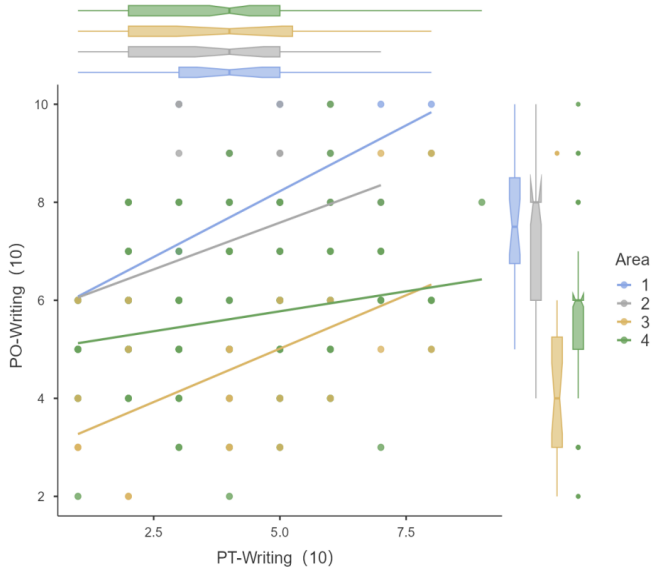

Figure 4 Scatterplot of Pre-test and Post-test Writing Scores Across Geographical Regions

For speaking performance, shown in Figure 5, the scatterplot reveals a linear relationship, with mostly parallel regression lines across the four regions. However, Area 4 shows a steeper slope, suggesting that students from this region may have improved their speaking skills at a faster rate. Despite this, the overall pattern supports the assumption of homogeneity of regression slopes. The assumptions of linearity and homogeneity of regression slopes are upheld, despite a steeper slope in Area 4.

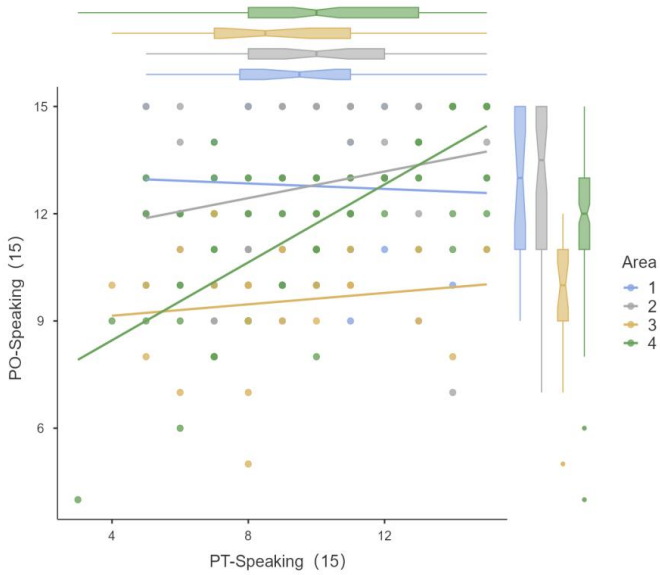

Figure 5 Scatterplot of Pre-test and Post-test Speaking Scores Across Geographical Regions

As in Figure 6, the scatterplot of total Business English performance shows a clear linear trend with parallel regression lines, confirming the homogeneity of regression slopes. The minor differences in score

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dispersion across regions do not significantly affect the overall trend. The assumptions of linearity and homogeneity of regression slopes hold for total Business English performance across geographical regions.

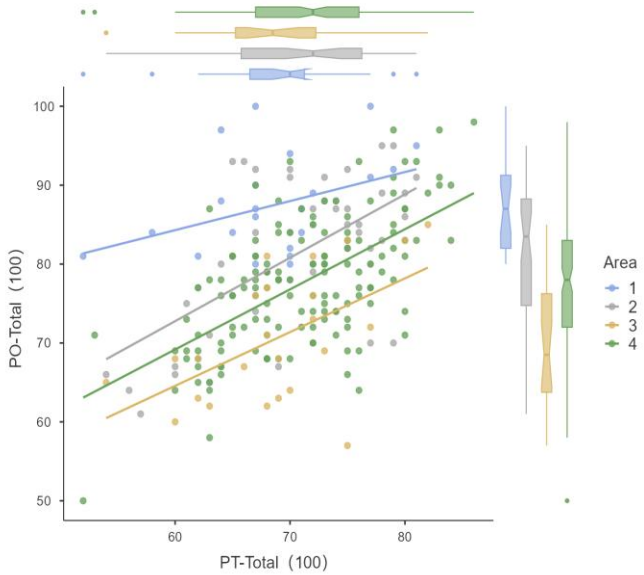

Figure 6 Scatterplot of Pre-test and Post-test Total Score Across Geographical Regions

In Figure 7, for reading performance by gender, the scatterplot shows a linear positive relationship between pre-test and post-test scores. The regression lines for male and female students are nearly identical, confirming homogeneity of regression slopes. The marginal boxplots suggest similar score distributions across gender. The assumptions of linearity and homogeneity of regression slopes hold for reading performance across gender.

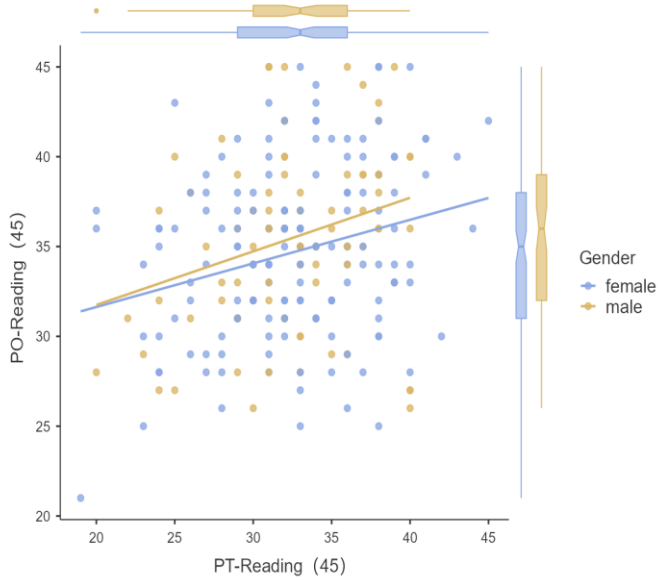

Figure 7 Scatterplot of Pre-test and Post-test Reading Scores Across Gender

For listening skills shown in Figure 8, the scatterplot indicates a strong linear trend, though the slope for male students appears slightly steeper than that for females. However, the difference is not substantial,

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and the lines remain roughly parallel, satisfying the homogeneity assumption. The assumptions of linearity and homogeneity of regression slopes are met, with minor slope variation.

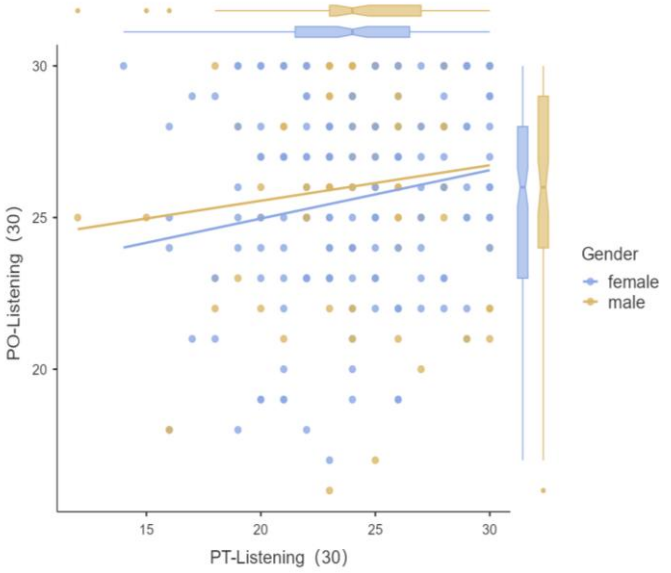

Figure 8 Scatterplot of Pre-test and Post-test Listening Scores Across Gender

For writing skills, shown in Figure 9, the scatterplot exhibits a strong linear relationship, with parallel regression lines for male and female students. The marginal boxplots and density distributions suggest no significant deviations in score dispersion, supporting the assumption. The assumptions of linearity and homogeneity of regression slopes hold for writing performance across gender.

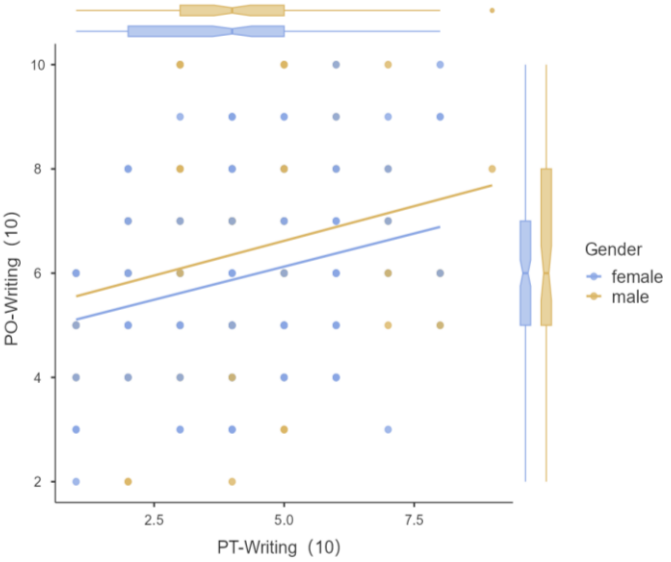

Figure 9 Scatterplot of Pre-test and Post-test Writing Scores Across Gender

The speaking performance scatterplot in Figure 10 reveals a consistent positive trend with nearly parallel regression lines. The slight variation in slopes does not indicate a significant violation of homogeneity. The assumptions of linearity and homogeneity of regression slopes hold for speaking performance across gender.

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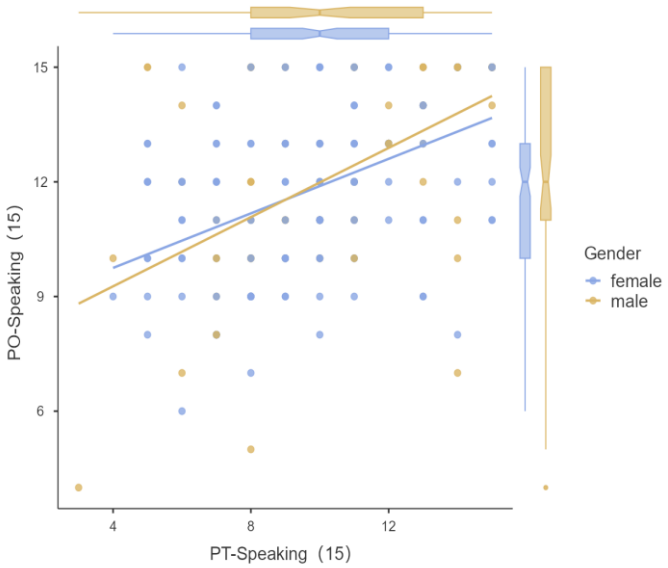

Figure 10 Scatterplot of Pre-test and Post-test Speaking Scores Across Gender

The scatterplot for total Business English performance, as shown in Figure 11, confirms a linear trend, with parallel regression slopes for male and female students. The distribution of scores is similar, and no significant interactions are detected. The assumptions of linearity and homogeneity of regression slopes are satisfied for total Business English performance across gender.

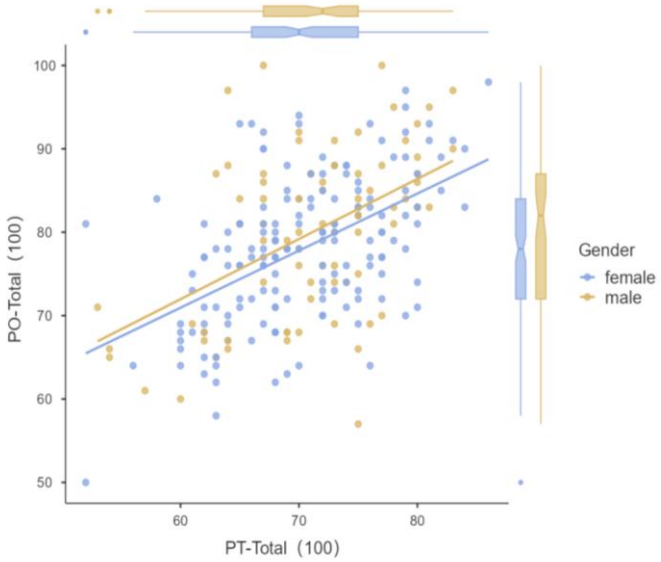

Figure 11 Scatterplot of Pre-test and Post-test Speaking Scores Across Gender

Hypothesis Testing for H1a–H1d: The Effect of Gender on Business English Performance

To examine whether gender has a statistically significant impact on students' Business English performance across listening, speaking, reading, and writing, ANCOVA was conducted while controlling for pre-test scores. This method allows for a more accurate assessment by adjusting for initial differences

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in covariates, ensuring that any observed effects are attributable to gender rather than prior proficiency (Field, 2018; Tabachnick & Fidell, 2019).

The interpretation of ANCOVA results is based on key statistical indicators. Statistical significance (p-value) determines whether gender has a meaningful effect on post-test scores after accounting for pre-test performance; a p-value < 0.05 suggests a significant effect, whereas $p \geq 0.05$ implies no statistical difference (Pallant, 2020). The F-statistic measures the variance explained by gender in relation to unexplained variance, with a higher F-value indicating a stronger effect. Additionally, effect size (partial eta squared, η^2) provides insight into the magnitude of the effect, where $\eta^2 = 0.01$ is small, $\eta^2 = 0.06$ is moderate, and $\eta^2 = 0.14$ is large (Cohen, 1988). The role of pre-test scores as covariates is also crucial; if pre-test scores significantly predict post-test outcomes ($p < 0.05$), this underscores the importance of prior proficiency in determining Business English performance (Tabachnick & Fidell, 2019).

Table 7 ANCOVA Results for the Effect of Gender on Business English Performance

		Sum of Squares	df	Mean Square	F	p
Reading	Gender	15.6	1	15.6	0.768	0.382
	PT-Reading（45）	437.1	1	437.1	21.519	<.001
	PT-Listening（30）	213.4	1	213.4	10.507	0.001
	PT-Writing（10）	66.7	1	66.7	3.285	0.071
	PT-Speaking（15）	137	1	137	6.746	0.01
	Residuals	4752.9	234	20.3		
Listening	Gender	2.78	1	2.78	0.304	0.582
	PT-Reading（45）	265.65	1	265.65	29.05	<.001
	PT-Listening（30）	125.66	1	125.66	13.741	<.001
	PT-Writing（10）	112.88	1	112.88	12.343	<.001
	PT-Speaking（15）	86.2	1	86.2	9.426	0.002
	Residuals	2139.85	234	9.14		
Writing	Gender	9.07	1	9.07	3.33	0.069
	PT-Reading（45）	56.45	1	56.45	20.7	<.001
	PT-Listening（30）	30.27	1	30.27	11.1	0.001
	PT-Writing（10）	70.3	1	70.3	25.78	<.001
	PT-Speaking（15）	9.13	1	9.13	3.35	0.069
	Residuals	638.03	234	2.73		
Speaking	Gender	0.634	1	0.634	0.159	0.69
	PT-Reading（45）	11.323	1	11.323	2.844	0.093
	PT-Listening（30）	0.499	1	0.499	0.125	0.724
	PT-Writing（10）	0.597	1	0.597	0.15	0.699
	PT-Speaking（15）	299.707	1	299.707	75.271	<.001
	Residuals	931.722	234	3.982		

Table 7 shows the ANCOVA result for the Effect of Gender on Business English Performance.

ANCOVA results for listening performance showed no statistically significant effect of gender on post-test scores ($F(1,234) = 0.304$, $p = 0.582$). This indicates that male and female students exhibited comparable improvements in listening skills after instruction. However, pre-test scores in reading ($F =$

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29.05, p < 0.001), listening (F = 13.741, p < 0.001), writing (F = 12.343, p < 0.001), and speaking (F = 9.426, p = 0.002) were all significant predictors of post-test listening performance. These findings suggest that prior proficiency in multiple language skills contributes more significantly to listening improvement than gender alone. Therefore, H1a is not supported.

Similarly, gender did not have a statistically significant effect on post-test speaking scores (F(1,234) = 0.159, p = 0.69). This suggests that both male and female students demonstrated similar progress in speaking ability. However, pre-test speaking scores had a strong and significant effect (F = 75.271, p < 0.001), indicating that students with higher initial speaking proficiency performed better in the post-test. These results highlight that prior speaking ability is a critical factor in post-test speaking performance, whereas gender does not significantly influence outcomes. Consequently, H1b is not supported.

The ANCOVA results for reading performance indicate that gender did not significantly impact post-test reading scores (F(1,234) = 0.768, p = 0.382). This means that male and female students performed similarly in reading after adjusting for pre-test differences. However, pre-test reading scores were a strong predictor of post-test reading performance (F(1,234) = 21.519, p < 0.001), reinforcing the importance of prior reading proficiency in determining post-test results. As gender does not appear to influence reading performance, H1c is not supported.

For writing performance, the ANCOVA results revealed no statistically significant effect of gender on post-test scores (F(1,234) = 3.33, p = 0.069). While this p-value is close to the significance threshold, it does not provide sufficient evidence to conclude a gender effect. However, pre-test scores in reading (F = 20.7, p < 0.001), listening (F = 11.1, p = 0.001), and writing (F = 25.78, p < 0.001) were all significant predictors of post-test writing performance. These findings emphasize that prior language proficiency plays a crucial role in writing performance, while gender does not have a meaningful impact. Therefore, H1d is not supported.

The results do not support H1a-H1d, as gender did not have a statistically significant impact on students' Business English performance in reading, listening, writing, or speaking when exposed to an AI-empowered blended learning platform. These findings align with prior research suggesting that gender differences in language learning outcomes tend to diminish when technology-enhanced instructional methods provide equitable access to learning resources and personalized feedback, fostering similar learning opportunities for both male and female students (Ellis, 2010; Vandergrift & Goh, 2012). Moreover, the significant effect of pre-test scores across all language skills underscores the critical role of prior proficiency and foundational knowledge in shaping students' post-test performance, reinforcing the necessity of adaptive learning strategies that accommodate individual learning trajectories in AI-driven language education (Field, 2018).

Overall, the statistical tests show that being male or female does not lead to major differences in how students perform in listening, speaking, reading, or writing after instruction. Instead, what they knew before the course played a larger role in determining their post-instruction scores.

Hypothesis Testing for H2a–H2d: The Effect of Geographical Background on Business English Performance

To determine whether students' geographical background significantly impacts their Business English performance across reading, listening, writing, and speaking skills, ANCOVA was conducted while controlling for pre-test scores. The findings in 8 indicate that geographical background had a statistically significant effect on all four language skills, suggesting that students from different regions performed differently after using the AI-empowered teaching platform.

Table 8 ANCOVA Results for the Effect of Geographical Background on Business English Performance

		Sum of Squares	df	Mean Square	F	p
Reading	Area	872	3	290.7	17.31	<.001
	PT-Reading（45）	556.8	1	556.8	33.15	<.001

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		Sum of Squares	df	Mean Square	F	p
	PT-Listening（30）	165.9	1	165.9	9.87	0.002
	PT-Writing（10）	66.3	1	66.3	3.95	0.048
	PT-Speaking（15）	159.4	1	159.4	9.49	0.002
	Residuals	3896.6	232	16.8		
Listening	Area	148	3	49.17	5.72	<.001
	PT-Reading（45）	301	1	300.82	34.98	<.001
	PT-Listening（30）	113	1	113.2	13.16	<.001
	PT-Writing（10）	114	1	113.91	13.25	<.001
	PT-Speaking（15）	100	1	100.05	11.63	<.001
	Residuals	1995	232	8.6		
Writing	Area	217.3	3	72.43	39.1	<.001
	PT-Reading（45）	72	1	71.99	38.86	<.001
	PT-Listening（30）	24.5	1	24.5	13.22	<.001
	PT-Writing（10）	71.4	1	71.37	38.52	<.001
	PT-Speaking（15）	13	1	13.04	7.04	0.009
	Residuals	429.8	232	1.85		
Speaking	Area	166.11135	3	55.37045	16.765	<.001
	PT-Reading（45）	15.10716	1	15.10716	4.574	0.034
	PT-Listening（30）	0.00221	1	0.00221	6.68E-04	0.979
	PT-Writing（10）	0.3763	1	0.3763	0.114	0.736
	PT-Speaking（15）	276.12277	1	276.12277	83.603	<.001
	Residuals	766.24417	232	3.30278		

ANCOVA results indicate that students' geographical background significantly influenced post-test listening performance ($F(3, 232) = 5.72$, $p < 0.001$). This suggests that students from different regions demonstrated varying levels of improvement in listening skills. Further analysis revealed that pre-test scores in reading ($F = 34.98$, $p < 0.001$), listening ($F = 13.16$, $p < 0.001$), writing ($F = 13.25$, $p < 0.001$), and speaking ($F = 11.63$, $p < 0.001$) were all significant predictors of post-test listening performance. These findings suggest that regional disparities in prior English exposure and instructional quality contribute to differences in Business English listening skills. Therefore, H2a is supported.

Similarly, ANCOVA results show that geographical background had a statistically significant effect on post-test speaking scores ($F(3, 232) = 16.77$, $p < 0.001$). This indicates that students from different regions performed differently in Business English speaking skills. The analysis also showed that pre-test speaking scores had a highly significant effect ($F = 83.603$, $p < 0.001$), reinforcing that initial proficiency strongly influences post-test speaking outcomes. Additionally, pre-test reading ($F = 4.574$, $p = 0.034$) was a significant predictor, suggesting that students with stronger reading abilities may have had an advantage in spoken language development. The significant effect of geographical background underscores the impact of regional differences in English-speaking environments and educational resources on students' spoken English proficiency. As a result, H2b is supported.

The ANCOVA results for reading performance indicate that students' geographical background had a significant effect on post-test reading scores ($F(3, 232) = 17.31$, $p < 0.001$). This suggests that students from different regions exhibited varying levels of reading proficiency after instruction. Additionally, pre-test reading scores were a strong predictor of post-test reading performance ($F(1,232) = 33.15$, $p < 0.001$),

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reinforcing the importance of prior reading skills in shaping post-test outcomes. The significant effect of geographical background suggests that regional disparities in educational quality, access to English-language materials, and curriculum focus impact Business English reading proficiency. Therefore, H2c is supported.

For writing performance, ANCOVA results reveal that geographical background had a statistically significant effect ($F(3, 232) = 39.1$, $p < 0.001$). This indicates that students from different regions demonstrated significantly different levels of improvement in Business English writing. Additionally, pre-test scores in reading ($F = 38.86$, $p < 0.001$), listening ($F = 13.22$, $p < 0.001$), and writing ($F = 38.52$, $p < 0.001$) were significant predictors of post-test writing performance, highlighting the importance of prior language skills in writing development. The strong effect of geographical background suggests that regional disparities in formal writing instruction, exposure to written English, and access to digital learning resources contribute to variations in Business English writing skills. Therefore, H2d is supported.

Students' performance varies significantly by region. This means that factors such as access to quality instruction and learning resources in different parts of the country are important in determining how well students learn Business English.

Hypothesis Testing for H3a–H3d: Interaction Between Gender and Geographical Background in Business English Performance

MANCOVA is an extension of ANCOVA that allows for the simultaneous analysis of multiple dependent variables while controlling for covariates, making it particularly suitable for investigating how gender and geographical background interact to influence multiple aspects of Business English proficiency (Tabachnick & Fidell, 2019).

Since this study examines four dependent variables (reading, listening, writing, and speaking scores), a univariate approach such as separate ANCOVAs for each skill would increase the risk of Type I errors due to multiple comparisons (Field, 2018). MANCOVA mitigates this issue by considering all dependent variables together, which improves statistical power and accounts for potential correlations among the language skills (Hair et al., 2010).

Furthermore, MANCOVA is particularly useful when exploring interaction effects, such as the combined influence of gender and geographical background. If a significant multivariate interaction effect is found, it suggests that the relationship between one independent variable (e.g., gender) and the dependent variables (language skills) depends on the level of another independent variable (e.g., geographical background). This provides deeper insights into whether gender-based differences in Business English proficiency are consistent across different regional backgrounds or if specific groups benefit differently from AI-powered blended learning environments (Pallant, 2020).

Before conducting Multivariate Analysis of Covariance (MANCOVA), it is crucial to assess whether the dataset meets key statistical assumptions to ensure the validity and reliability of the results. First, multivariate normality must be verified, as MANCOVA assumes that the residuals of the dependent variables follow a multivariate normal distribution. This can be assessed through skewness and kurtosis values, as well as residual plots (Tabachnick & Fidell, 2019). Second, the homogeneity of variance-covariance matrices must be examined using Box's M test, which ensures that the variance-covariance structures of the dependent variables are similar across groups (Field, 2018). If this assumption is violated, alternative test statistics such as Pillai's Trace may be more appropriate (Pallant, 2020). Third, linearity should be checked using scatterplots, ensuring that the relationships between covariates and dependent variables are linear, as non-linearity can distort MANCOVA results (Hair et al., 2010). Lastly, homogeneity of regression slopes must be tested to confirm that covariates influence all groups equally, preventing biased adjustments in the model (Tabachnick & Fidell, 2019). Meeting these assumptions strengthens the robustness of MANCOVA findings, allowing for accurate conclusions regarding the impact of gender and geographical background on Business English performance in an AI-empowered learning environment.

Before proceeding with the MANCOVA analysis for H3, it is essential to ensure that all necessary assumptions are met. The assumptions of multivariate normality, linearity, and homogeneity of regression

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slopes were already tested prior to conducting ANCOVA for H1 and H2. The normality of the dataset was assessed using skewness and kurtosis values, confirming that all variables fell within acceptable thresholds (Hair et al., 2010). Linearity was verified through scatterplots, ensuring that the relationships between pre-test and post-test scores were consistent across all levels of the independent variables (Field, 2018). Additionally, the assumption of homogeneity of regression slopes was examined by testing for interactions between the covariate (pre-test scores) and the independent variables, confirming that the slopes did not significantly differ across groups (Tabachnick & Fidell, 2019). Given that these assumptions have already been satisfied, the only remaining assumption to check before proceeding with MANCOVA is the homogeneity of variance-covariance matrices, which has been evaluated using Box's M test.

Table 9 Box's M Test for Homogeneity of Variance-Covariance Matrices

χ^2	df	p
75.1	70	0.317

In Table 9, the Box's M test yields a χ^2 value of 75.1 with 70 degrees of freedom (df) and a p-value of 0.317. Since the p-value is well above the 0.001 threshold, the assumption of homogeneity of variance-covariance matrices is met. This confirms that the variance-covariance matrices are not significantly different across gender and geographical background groups, allowing us to proceed with MANCOVA without concerns about violating this assumption (Field, 2018).

Table 10 MANCOVA Results for the Interaction Between Gender and Geographical Background on Business English Performance

		value	F	df1	df2	p
Area	Pillai's Trace	0.5374	12.384	12	681	<.001
	Wilks' Lambda	0.518	14.02	12	596	<.001
	Hotelling's Trace	0.82798	15.433	12	671	<.001
	Roy's Largest Root	0.68913	39.108	4	227	<.001
Gender	Pillai's Trace	0.00616	0.349	4	225	0.845
	Wilks' Lambda	0.994	0.349	4	225	0.845
	Hotelling's Trace	0.0062	0.349	4	225	0.845
	Roy's Largest Root	0.0062	0.349	4	225	0.845
Area ✻ Gender	Pillai's Trace	0.04875	0.937	12	681	0.509
	Wilks' Lambda	0.952	0.933	12	596	0.513
	Hotelling's Trace	0.04981	0.928	12	671	0.518
	Roy's Largest Root	0.02807	1.593	4	227	0.177
PT-Reading（45）	Pillai's Trace	0.23719	17.491	4	225	<.001
	Wilks' Lambda	0.763	17.491	4	225	<.001
	Hotelling's Trace	0.31094	17.491	4	225	<.001
	Roy's Largest Root	0.31094	17.491	4	225	<.001
PT-Listening（30）	Pillai's Trace	0.08357	5.129	4	225	<.001
	Wilks' Lambda	0.916	5.129	4	225	<.001
	Hotelling's Trace	0.09119	5.129	4	225	<.001
	Roy's Largest Root	0.09119	5.129	4	225	<.001
PT-Writing（10）	Pillai's Trace	0.15795	10.552	4	225	<.001
	Wilks' Lambda	0.842	10.552	4	225	<.001
	Hotelling's Trace	0.18758	10.552	4	225	<.001
	Roy's Largest Root	0.18758	10.552	4	225	<.001

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		value	F	df1	df2	p
PT-Speaking（15）	Pillai's Trace	0.28934	22.902	4	225	<.001
	Wilks' Lambda	0.711	22.902	4	225	<.001
	Hotelling's Trace	0.40714	22.902	4	225	<.001
	Roy's Largest Root	0.40714	22.902	4	225	<.001

Table 10 presents results from the four primary multivariate test statistics: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, which provide insight into the overall impact of the independent variables on multiple dependent variables simultaneously (Tabachnick & Fidell, 2019).

The MANCOVA results indicate that geographical background has a statistically significant effect on Business English performance across all four language skills. Wilks' Lambda ($\Lambda = 0.518$, $F = 14.02$, $p < 0.001$) confirms that students from different regions exhibited significant variations in their performance. This finding suggests that regional differences in access to English education, instructional resources, and socio-economic conditions may contribute to disparities in Business English proficiency.

However, gender alone did not have a statistically significant impact on Business English performance (Wilks' Lambda = 0.994, $F = 0.349$, $p = 0.845$). This aligns with existing literature, which suggests that gender differences in language learning tend to diminish in structured learning environments, particularly when digital or AI-based instructional methods provide equal opportunities for all learners (Vandergrift & Goh, 2012).

Regarding the interaction effect between gender and geographical background, the results were not statistically significant (Wilks' Lambda = 0.952, $F = 0.933$, $p = 0.513$). This indicates that the influence of geographical background on Business English performance does not vary by gender. In other words, both male and female students from different regions exhibit similar patterns of performance, with geographical background being the dominant factor influencing outcomes rather than an interaction between gender and region.

The MANCOVA results for listening performance indicate that the interaction effect between gender and geographical background was not significant (Wilks' Lambda = 0.916, $F = 5.129$, $p < 0.001$ for geographical background alone, but $p = 0.513$ for the interaction effect). This suggests that while students from different geographical regions exhibited significant differences in Business English listening proficiency, these differences were consistent across male and female students. Consequently, H3a is not supported.

Similarly, the results for speaking performance show that the interaction effect between gender and geographical background was not significant (Wilks' Lambda = 0.711, $F = 22.902$, $p < 0.001$ for geographical background alone, but $p = 0.513$ for the interaction effect). This finding suggests that regional differences significantly impact Business English speaking proficiency, but these differences do not vary by gender. Both male and female students within the same region exhibited comparable improvements or challenges in spoken English performance. Thus, H3b is not supported.

For reading performance, geographical background had a significant effect (Wilks' Lambda = 0.763, $F = 17.491$, $p < 0.001$), indicating that students from different regions performed differently in Business English reading. However, the interaction between gender and geographical background was not statistically significant ($p = 0.513$), reinforcing that regional disparities in reading skills were similar across both male and female students. Thus, H3c is not supported.

Lastly, in writing performance, geographical background was a significant predictor (Wilks' Lambda = 0.842, $F = 10.552$, $p < 0.001$), confirming regional differences in Business English writing proficiency. However, the interaction effect between gender and geographical background was not statistically significant ($p = 0.513$), meaning that both male and female students from the same region exhibited similar patterns of performance in Business English writing. As a result, H3d is not supported.

The MANCOVA results consistently indicate that geographical background significantly influences Business English proficiency across listening, speaking, reading, and writing, but this effect does not differ

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between male and female students. In other words, the regional disparities in performance apply equally to both genders, with no evidence of a combined effect between gender and region.

These findings suggest that factors such as regional educational policies, resource availability, and socio-economic conditions play a more substantial role in Business English proficiency than gender-related differences. This aligns with research indicating that language acquisition is primarily shaped by environmental and instructional factors rather than gender-specific learning advantages (Ellis, 2010; Vandergrift & Goh, 2012).

In everyday language, this means that while regional factors play a big role in influencing students' language skills, these effects are similar for both male and female students. In other words, the differences seen among regions affect all students equally, regardless of gender.

Summary of Hypothesis Testing

The results of hypothesis testing indicate that gender does not have a statistically significant impact on Business English performance across listening, speaking, reading, and writing (H1a–H1d). However, geographical background significantly influences all four language skills (H2a–H2d), suggesting that regional differences in educational resources and exposure to English contribute to disparities in proficiency. Finally, the interaction effect between gender and geographical background was not significant (H3a–H3d), meaning that regional differences in Business English performance apply equally to both male and female students.

The findings suggest that regional disparities play a more significant role in Business English proficiency than gender-related differences. This highlights the importance of addressing educational resource allocation and instructional strategies in different geographical regions to bridge the performance gap in Business English learning.

Table 11 Summary Table of Hypothesis Testing

Hypotheses	Statement	Result after Analysis
H1a	Gender has a statistically significant impact on Business English listening performance	Not Supported
H1b	Gender has a statistically significant impact on Business English speaking performance	Not Supported
H1c	Gender has a statistically significant impact on Business English reading performance	Not Supported
H1d	Gender has a statistically significant impact on Business English writing performance	Not Supported
H2a	Geographical background significantly influences Business English listening performance	Supported
H2b	Geographical background significantly influences Business English speaking performance	Supported
H2c	Geographical background significantly influences Business English reading performance	Supported
H2d	Geographical background significantly influences Business English writing performance	Supported
H3a	There is a statistically significant interaction between gender and geographical background affecting Business English listening performance	Not Supported
H3b	There is a statistically significant interaction between gender and geographical background affecting Business English speaking performance	Not Supported

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Hypotheses	Statement	Result after Analysis
H3c	There is a statistically significant interaction between gender and geographical background affecting Business English reading performance	Not Supported
H3d	There is a statistically significant interaction between gender and geographical background affecting Business English writing performance	Not Supported

The study found that while students' gender does not significantly affect their performance in Business English, the region they come from does have a notable impact. However, there is no evidence that gender and regional factors interact in a way that creates additional differences. This emphasizes the importance of addressing regional disparities to improve language learning outcomes.

Discussion

This study examined the impact of gender and geographical background on Business English performance in an AI-powered blended learning environment using the FLIT platform. The findings contribute to the growing body of research on AI-assisted language learning, particularly within Business English education, by highlighting how individual learner characteristics influence listening, speaking, reading, and writing proficiency in such settings.

The Effect of Gender on Business English Performance

The results indicate that gender did not have a statistically significant impact on any of the four language skills. This finding suggests that AI-powered blended learning environments, such as those provided by the FLIT platform, can mitigate traditional gender disparities in language learning. The platform's real-time feedback, adaptive assessments, and tailored learning materials appear to offer an equitable learning experience for all students, regardless of gender. These results align with previous research showing that technology-enhanced instruction can neutralize gender-based performance differences, ensuring that both male and female learners benefit equally from personalized support and adaptive learning pathways.

The Effect of Geographical Background on Business English Performance

In contrast, geographical background significantly influenced students' performance across all language skills. Students from urban areas generally outperformed their rural counterparts, underscoring the role of socio-economic factors, access to high-quality English education, and digital resources in language acquisition. Despite the advantages provided by the FLIT platform's AI-driven analytics, students in rural areas faced challenges that hindered their ability to fully capitalize on AI-assisted learning. This suggests that while the platform offers advanced learning support, its benefits are moderated by external factors such as digital literacy and infrastructural limitations in rural settings.

The Interaction Effect Between Gender and Geographical Background

The findings have important implications for leveraging AI in language education to promote equity. Although AI-powered platforms can equalize opportunities by offering personalized instruction and feedback that diminishes gender disparities, they may not fully overcome the challenges imposed by regional disparities. To achieve more equitable learning outcomes, it is essential to implement additional support mechanisms for students in under-resourced regions. This could include:

Enhanced Digital Literacy Training: Tailored programs to boost technological skills among rural students, ensuring they can effectively utilize AI-driven tools.

Targeted Support Programs: Development of mentorship and supplementary resource initiatives specifically designed to address the unique challenges faced by rural learners.

Infrastructure Improvements: Investments in internet connectivity and digital infrastructure in rural areas to enable smoother access to AI-enhanced learning platforms.

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Region-Specific Instructional Strategies: Customization of AI-driven content to reflect the unique educational needs and cultural contexts of different regions, ensuring relevance and engagement for all learners.

The Interaction Effect Between Gender and Geographical Background

The study found no significant interaction between gender and geographical background, indicating that the impact of regional disparities on Business English performance is consistent across both male and female students. In essence, while AI-powered platforms effectively neutralize gender differences, they do not inherently resolve the urban-rural divide. This outcome reinforces the need for policymakers and educators to focus on targeted interventions that address the broader environmental and socio-economic factors influencing language learning.

Overall, the findings underscore the potential of AI-powered blended learning to provide equitable educational experiences across genders. However, they also reveal that regional disparities persist, suggesting that technological advancements must be complemented by policy-level and infrastructural improvements to fully realize the benefits of AI in language education. Future research should investigate innovative strategies that integrate AI with region-specific support systems to create more inclusive and effective learning environments for diverse student populations.

Conclusion

This study investigated the effects of gender and geographical background on Business English performance in an AI-powered blended learning environment using the FLIT platform. The results indicate that gender did not significantly impact students' performance, suggesting that AI-enhanced learning environments can help neutralize traditional gender differences in language acquisition. However, geographical background played a significant role in Business English proficiency, with urban students outperforming their rural counterparts. Additionally, no significant interaction effect was found between gender and geographical background, meaning that gender-related differences were consistent across both urban and rural contexts.

The findings contribute to the growing body of research on AI-assisted language learning, highlighting both its potential and limitations. While AI-driven platforms can offer personalized, data-driven instruction that reduces gender disparities, they may not fully eliminate regional inequalities in language proficiency. This underscores the need for further interventions to support students from disadvantaged backgrounds, ensuring that AI-powered educational tools are accessible and effective for all learners.

Recommendation

For Educators and Institutions

Educators and institutions should develop tailored digital literacy programs that specifically target rural students. For instance, structured workshops or semester-long training modules can be introduced to help these students navigate AI platforms like FLIT effectively. Such programs should include hands-on sessions, online tutorials, and real-world simulations—such as business negotiation scenarios using AI-powered speech recognition and writing assistance—to improve fluency and accuracy in Business English. Additionally, integrating advanced AI tools that provide immediate, detailed feedback on language performance can further enhance learning outcomes. Combining these digital interventions with traditional classroom activities, such as interactive group projects, role-playing exercises, and case studies, can ensure that AI-powered instruction is effectively reinforced by collaborative, instructor-led learning experiences.

For Policymakers

Policymakers play a crucial role in bridging the urban-rural digital divide by implementing targeted policy changes and infrastructure investments. Increasing funding for broadband and digital infrastructure in underdeveloped areas is essential to ensure all students have reliable access to AI-based educational tools. Alongside these infrastructural improvements, government-funded teacher training programs should

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be established to equip educators—especially in rural schools—with the skills needed to integrate AI-assisted technologies into their teaching practices. Additionally, policymakers should consider developing inclusive digital education policies that provide incentives for public-private partnerships, ensuring that schools in disadvantaged regions receive the latest AI-powered software and hardware to support effective learning.

For Future Research

Future research should focus on the long-term effects of AI-driven instruction on Business English proficiency. Longitudinal studies tracking students' progress beyond immediate post-test results could provide valuable insights into the sustainability of initial gains. Researchers are encouraged to investigate how individual learning styles, motivation, and cognitive abilities interact with AI-based learning environments, to develop more adaptive and personalized AI models. Furthermore, exploring emerging technologies such as virtual reality-based language learning, AI-powered conversational agents, and gamified educational experiences could reveal new strategies for optimizing AI-assisted instruction. Together, these research directions can inform the creation of more equitable and effective learning models that cater to diverse student populations.

By implementing these recommendations, educators, institutions, and policymakers can enhance the impact of AI-powered blended learning, making Business English instruction more accessible, effective, and inclusive for all students. Future research should continue to refine AI-assisted teaching methodologies, ensuring that advancements in educational technology are leveraged to their full potential in language learning.

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