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RECEIVED 01 August 2023

ACCEPTED 25 March 2024

PUBLISHED 10 April 2024

CITATION

Tao Y, Yu L, Luo L and Zhang H (2024) Effect of blended teaching on college students' EFL acquisition. *Front. Educ.* 9:1264573. doi: 10.3389/educ.2024.1264573

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Effect of blended teaching on college students' EFL acquisition

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The research into the efficacy of blended EFL (English as a Foreign Language) teaching at the collegiate level holds significant importance for comprehending and implementing this novel pedagogical approach on a larger scale within universities. Within this domain, scholars have primarily concentrated on feedback mechanisms and quality assurance, while comparatively neglecting the advancement of college students' foreign language proficiency and the individual variances in the acceptance and rewards of blended teaching across distinct language proficiency groups. In light of this, leveraging micro-data from a provincial normal university's blended college English teaching, this study employs R 3.6.1 and R Studio to implement multiple linear regression and conditional quantile models so as to assess the impact of blended teaching on different language proficiency groups across four dimensions: listening, reading, writing, and overall language proficiency. To mitigate endogenous system risk, students admitted to the same major are selected as samples and their data undergoes additional screening, excluding learners who failed the CET4 exam or did not participate in the CET6 exam. After employing purposive sampling techniques, a valid sample of 676 learners is established, comprising 363 learners in the experimental group for blended teaching intervention and 313 learners in the control group receiving traditional teaching. The study results indicates that the samples had random characteristics. The study findings suggest the following: (1) Blended teaching has a significant positive impact on enhancing the efficiency of English acquisition. (2) The effectiveness of blended teaching in improving learners' reading, listening, and writing skills follows a sequential decrease, exhibiting a downward trend as students' language ability increases. This indicates that blended teaching facilitates the acquisition of foundational language knowledge, however, its impact on more advanced language processing abilities is limited. (3) Blended teaching demonstrates a range effect, primarily benefiting learners at the intermediate level and below in terms of enhancing their language proficiency. Conversely, learners at the medium-high and high proficiency levels derive comparatively lesser benefits from this approach. This study introduces a new methodology by employing multiple linear regression and conditional quantile models to assess the impact of blended teaching. This methodology not only enables us to examine the overall impact of blended teaching, but also allows assessment of its effect on different proficiency groups, helping to identify its effectiveness on individual learners across four dimensions.

KEYWORDS

college English, blended teaching, EFL, demographic characteristics, multiple linear regression, quantile

1 Introduction

Due to the COVID-19 epidemic, the teaching method of English courses in colleges is constantly changing, gradually evolving from traditional classroom teaching to blended teaching. *Guidelines on College English Teaching (National Advisory Committee on TEFL in Higher Education under the Ministry of Education, 2020)* advocates that college English

courses should implement blended teaching model to enable students to develop active, independent and personalized learning, and encourage teachers to make full use of online platforms to provide students with online and offline learning access and rich resources that combine classroom instruction with modern information technology. Therefore, to ensure efficiency of this teaching mode, the assessment and promotion of its impact has become an urgent problem for educators and researchers to solve.

Blended teaching is defined in two distinct categories on an international scale—the narrow and broad senses. Within the context of the narrow sense, blended teaching is regarded as the effective integration of face-to-face teaching and online learning, aligning with the teaching objectives (Garrison, 2009). This perspective underscores the fusion of classroom teaching and information technology within curriculum design and knowledge dissemination, thereby comprehensively optimizing a diverse range of online and offline learning resources and activities (Whittaker, 2013). Therefore, two fundamental elements the narrow sense accentuates are self-directed online learning and face-to-face teaching. While this definition of blended learning appears clear, it exhibits evident shortcomings, as the focal point of teaching design should not revolve around the proportion of online and offline teaching, but rather the seamless integration of these two modalities (Hu, 2021). Hence, the broad sense emerges, which believes that blended teaching includes the mixing of teaching theory, media, mode, methods and other elements. This perspective claims that blended teaching comprises a flexible integration of curriculum and technology, aiming to enhance effectiveness and cost-efficiency (Banados, 2006). Irrespective of the specific technological tools employed, blended teaching may involve any of the distinct types as follows: the integration of traditional classroom teaching with online teaching, the utilization of diverse digital media and technology tools, and the fusion of various teaching methodologies (Sharma, 2010). This interpretation embraces two advantages: first, it enhances the flexibility of the blending concept, covering the blending mode under different environmental and technical conditions; second, it promotes the resilience of blending, which can reflect the essence of the teaching mode and enable different blending practice to have common ground. The feature of combined flexibility and resilience is precisely what makes the mode so popular, allowing teachers and students to understand and implement blending in a personalized, functional context. With the rapid development of Internet and mobile technology, especially the advent of the “Internet Plus” era, the concept of blended teaching has also developed since 2010. Yen and Lee (2011) perceive blended teaching as a fundamental transformation and redesign of teaching models, proposing three key characteristics: (1) a shift from a teacher-centered approach to a student-centered approach; (2) the reinforcement of interactions among students, between students and teachers, students and content, as well as students and external resources; (3) the adoption of an evaluation mechanism that combines formative and summative assessments. In sum, blended teaching is defined as an optimal combination and integration of teaching modalities, resources, and strategies, aiming to achieve the ultimate teaching purpose. It emphasizes the need to build a teacher-led and student-centered teaching mode that creates “autonomous, inquiring and cooperative” learning atmosphere, thus conducive to the cultivation of innovative talents (Li, 2014; Fakhir and Ibrahim, 2018).

2 Literature review

Contemporarily, blended teaching has gained widespread adoption in higher education, particularly in the domain of second language teaching, where notable advancements have been made on a substantial scale in university education. Numerous scholars (López-Pérez et al., 2011; Chen et al., 2015; Feng et al., 2016; Ige and Hlalele, 2017; Jiang and Hu, 2018; Lv, 2021; Ma et al., 2021) have acknowledged the positive impact of blended teaching on EFL. By articulating through six testable propositions, Dawson (2015) provided a potential agenda for research about blended approaches and constructed a theoretical argument that blended approaches might improve student motivation and help manage cognitive load of basic knowledge. It is widely accepted that this teaching mode can optimize the learning process, enhance the independent learning capabilities of college students, improve overall satisfaction with the learning experience, and foster the development of innovative and critical thinking skills (Wu et al., 2010; Diep et al., 2017).

However, there remains a dearth of empirical studies into the impact of blended teaching by using advanced statistical methods (such as quantitative regression and structural equation models). Most of the current researches have chosen to adapt scales to make questionnaires, and then collect interviews and texts for further verification. Simple experimental and survey methods are often used to compare the mean values of academic performance, learning satisfaction, attitude and ability. As a result, while theoretical studies posit that blended teaching may alleviate cognitive load and yield positive effects in EFL (Henrie et al., 2015; Ilic et al., 2015; Kintu et al., 2017; Nazzal and Alradi, 2020), the empirical findings are somewhat incongruous. For instance, with regard to overall language proficiency, Fakhir and Ibrahim (2018), Oweis (2018), Nazzal and Alradi (2020) discovered that university students who received blended teaching exhibited a moderate enhancement in their English scores. Conversely, Kwak et al. (2015) claimed that blended teaching had either no effect or a detrimental impact on the learning process. In a study conducted by Gao (2021), the CET 4 (College English Test Band Four) score, known for its high reliability and validity, was employed as a measure of language proficiency. The findings revealed that students’ foreign language ability exhibited only marginal improvement or even no noticeable difference in the later stages of blended teaching. Regarding the decomposable indicators of language proficiency, Hou (2010) verified the impact of blended English listening teaching, but determined that this teaching modality failed to enhance students’ writing skills. Conversely, Meng’s (2011) analysis indicated that blended teaching contributed to a moderate improvement in students’ writing skills. Jiao et al. (2017) attempted to reform English writing teaching by employing the ICLASS platform. Through tests, questionnaires and interviews, they came to the conclusion that the experimental group that conducted blended teaching achieved significantly higher scores in applied writing than the control group using traditional mode. In terms of listening and speaking skills, Liu (2016) research demonstrated a slight difference in students’ English listening and speaking abilities before and after experiment, contradicting the findings of Hou (2010). The conflicting findings might be caused by the different sample populations they used, because the sample students in their studies

were from different colleges and of different English language proficiency. What's more, the contradiction was also attributable to the different methodologies used in the studies. Some studies relied on convenience sampling and utilized qualitative analysis while others adopted quantitative investigation.

These studies have significantly contributed to the scholarly understanding of blended teaching in EFL. Through continuous experimentation and innovation, they have revolutionized traditional teaching through information technology. Their researches expounded on the understanding of blended teaching and inquired into its implementation, which helps us to redesign our curriculum for this teaching mode. Meanwhile, strenuous effort was made to explore the problems encountered, so as to offer solutions and improve blended teaching efficiency. However, they also exhibit certain limitations in terms of experimental design and research methodologies. Primarily, these studies often rely on convenience sampling and utilize parallel classes as the subjects of experimental research, without strictly controlling for the experimental environment. This approach leads to selective grouping and compromises the unbiased estimation of teaching effects. Secondly, these studies primarily employ qualitative analysis methods to examine the correlation between a single explanatory variable (i.e., student participation in blended teaching) and a response variable (language performance or course satisfaction). However, they often overlook the influence of other crucial control variables, thereby limiting the explanatory power and generalizability of their findings. Moreover, the current research on blended second language teaching predominantly focuses on changes in the mean values of classroom effectiveness, neglecting the individual differences among learners. Accordingly, they fail to comprehensively and consistently describe the impact of blended teaching on learners of varying proficiency levels while this aspect is closely tied to the fairness and applicability of blended teaching in English teaching practice.

Within the cognitive domain, researchers also contributed a lot to the investigation of EFL teaching. For instance, according to Skehan's (1998) three-factor model of language preference, the speech decoding ability plays a pivotal role in the initial phase of acquiring a second language. Subsequently, it undergoes a period of steady growth until reaching a certain threshold, beyond which the contribution of speech decoding ability to EFL diminishes significantly. Anderson et al. (2000) revised the classification theory of educational objectives within Bloom's cognitive domain and claimed that reading should be considered as primary cognition, including memory, comprehension, and application, and listening and writing be regarded as advanced cognition involving analysis, evaluation, and creation. Their studies set a foundation for the assessment of blended teaching impact on composable English indicators such as reading, listening and writing.

In effect, previous research has demonstrated that early-stage academic achievement variables (College entrance examination score, final test scores, proficiency test scores) and demographic variables (age, gender, and major in school) play a significant role in influencing the effectiveness of blended teaching. For instance, Calimeris and Sauer (2015) utilized the ordinary least square (OLS) model to control for learners' socioeconomic status (SES)

and prior academic performance. They examined the impact of blended teaching in economics courses and discovered that the experimental group achieved significantly higher scores in mid-term and final exams compared to the control group. Similarly, after controlling for these variables, Foldnes (2016), He et al. (2016), as well as Asarta and Schmidt (2017) found that students who participated in blended teaching outperformed those who received traditional teaching in the fields of economics, science, and engineering. By controlling for early-stage academic achievement variables and demographic variables in their studies, they have conducted a more accurate examination of the blended teaching impact in their disciplines. This methodology shed light on the research design of our investigation for assessment of EFL blended teaching.

Based on the aforementioned understanding, by controlling for early-stage academic achievement variables and demographic variables of the sample students, this study will adopt advanced statistical methods such as multiple linear regression and conditional quantile regression to assess the impact of EFL blended teaching. The multiple linear regression model is employed for two reasons: Firstly, it can handle the relationship between multiple independent variables and a dependent variable, enabling capture of the combined influence of multiple independent variables on the dependent variable. The modeling flexibility allows the model to better adapt to complex data patterns and relationships. Secondly, the multiple linear regression model assumes a linear relationship between the independent variables and the dependent variables, which makes the results of the model easier to interpret and understand. The regression coefficients allow us to determine the expected change in the dependent variable by the change in unit independent variables, making the results of the model more practical and interpretable. However, if there are outliers in the sample data, this model estimates can be biased significantly. Sometimes we want to study not only the desired mean of the response variable, but also the global distribution of the response variable (such as a certain quantile of the response variable), in which case quantile regression is required. Quantile regression applies more relaxed conditions, describes the global characteristics of the response variable, and mines richer information. Different regression coefficients of diverse quantiles indicate that explanatory variables have different influences on various levels of response variables, and we can obtain the influence of explanatory variables on the trend of quantiles of response variables.

This assessment is conducted by examining the composition of language ability and individual differences, while controlling for relevant academic performance and demographic variables. Therefore, a more comprehensive examination of the blended teaching effects on EFL is undertaken. To begin, the study employs a multiple linear regression model to determine the relationship between blended teaching and college students' English language proficiency. Subsequently, a conditional quantile regression model is utilized to explore the influence boundaries of blended teaching. Finally, the estimated results from both analyses are synthesized to determine the effectiveness of blended teaching. This study will address the following three key issues:

- (1) To what extent does blended teaching influence English reading, listening, writing, and overall English proficiency of college students?
- (2) How do English language acquisition situations vary among students at different proficiency levels within a blended teaching environment?
- (3) What is the distribution of the impact of blended teaching across the entire sample interval?

In view of the divergences in the existing research results caused by employment of different sample populations and research methodologies, it is necessary to control for variables and adopt more advanced statistical methods, such as multiple linear regression and conditional quantile regression, to achieve a more accurate assessment of blended teaching impact on EFL, thus offering practical suggestions for teaching design and helping to improve English teaching efficiency.

3 Materials and methods

3.1 Research design

The study summarized five fundamental components of blended teaching, namely offline learning (face-to-face teaching), online learning (MOOC), learning tasks, learning platforms, and assessment. Therefore, according to Lv's (2021) study, the teaching experiment incorporated four distinct procedures (Table 1): resource construction, pre-class self-study, face-to-face teaching, and learning assessment.

First, the university established a user-friendly learning platform. Subsequently, the teaching team developed MOOCs and compiled lists of learning tasks based on the "New Horizon College English" textbook series. These resources included various aspects such as vocabulary, grammar, reading, listening, translation, and writing, which were then uploaded onto the platform. Students had the flexibility to access the platform and fulfill tasks and assessments at their convenience. Prior to each class, teachers assigned online self-learning tasks and provided [Supplementary material](#). The experimental group students were required to dedicate 2 h to online learning and submit any encountered problems or difficulties during their self-study. Based on the data obtained from the platform, personalized guidance was subsequently provided to address individual needs. During the face-to-face teaching phase, teachers and students collaborated to review and consolidate the previously covered learning content. Various learning activities, such as discussions and group cooperation, were employed to facilitate in-depth understanding. Meanwhile, teachers utilized the platform data and individual learning situations to provide targeted interventions. In the evaluation phase, teachers designed assessment scales for the course and offered timely feedback to students. Students reinforced their learning by completing assignments, exercises, and tests.

In contrast, the control group followed traditional teaching methods. Students were provided sheets for preview tasks before class and required to undergo tests in class to check their work. Teachers imparted knowledge face-to-face in class and organized students to conduct discussion, idea presentation and

group cooperation in class. Homework was assigned in class and students were supposed to hand in their work before deadline. Students' work was then evaluated by teachers based on the same assessment scale as the experiment group. Additionally, all learners were required to complete five essays over the course of the semester. Topics of the essays were closely related to the texts they had learned, including college life, humanities study, modern technology, sports and marriage. Besides, essays of both groups were evaluated in accordance with the CET6 essay grading scales. To guarantee score validity and fairness, each grading was crosschecked by two other teachers.

Although students of the control group had access to the resources on the platform, they were not required to complete tasks on the learning platform. At the end of the intervention period, two teachers checked the online learning data of the control group and found that only four students registered and had studied online for a total of 2.7 h, which was minimal and was not enough to introduce a confounding variable in the study. It's worth noting that to eliminate risks of performance bias, students in both groups did not know which group they belong to.

To minimize the impact of the macro environment on learners' behavior, the experiment and control groups maintained consistent learning conditions throughout the duration of the study. This entailed the presence of seven lecturers, each possessing a teaching experience of 9 years. The teaching materials, including textbooks, course notes, and assigned exercises, were identical for both groups. Any issues that arose during the study were duly addressed and clarified by the teachers.

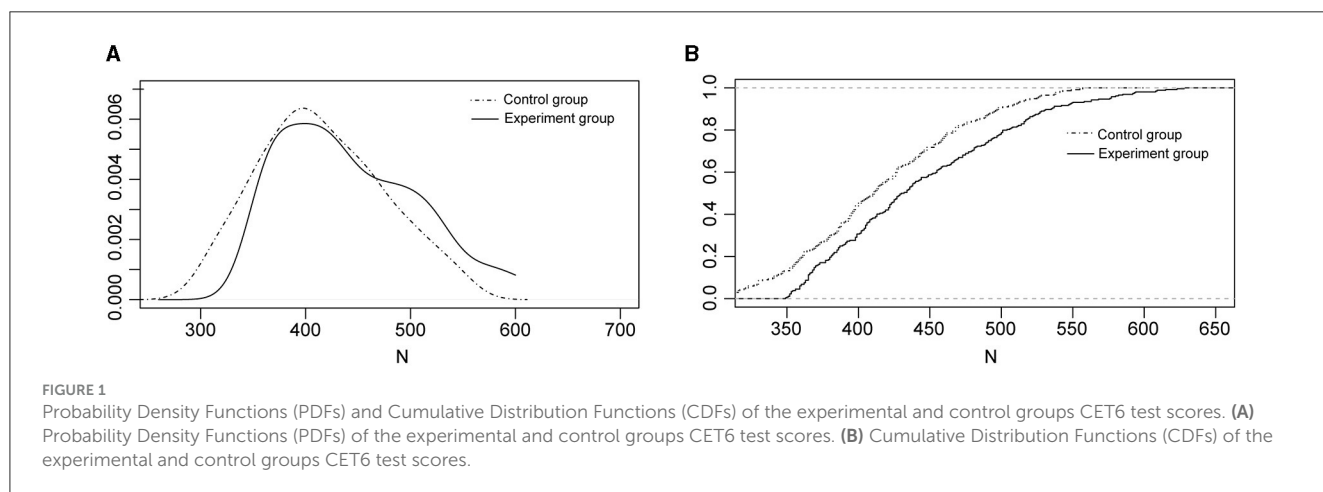
Based on the collected data, this study first adopted SPSS to calculate the mean value and variance of samples' demographic variables to guarantee the randomness of samples. Then we observed and compared the CET6 scores of the experiment and control groups to assess the overall impact of blended teaching. In addition, the study plotted the Probability Density Functions (PDFs) and Cumulative Distribution Functions (CDFs) pertaining to the CET6 scores within both the experimental and control groups (Figure 1). Premised on the results of basic statistical analysis, it is readily apparent that both the response variable Y and the CET4 test scores exhibit characteristics of dispersed data distribution, accompanied by the presence of concurrent maximum and minimum values. Therefore, it is necessary to regulate additional variables that influence English proficiency in order to derive a more accurate estimation of the impact of blended teaching. Subsequently, R 3.6.1 and R Studio were then employed to conduct multiple linear regression and conditional quantile models. By making a comparison across different proficiency groups, mean values for various indicators of the experimental group were compared to the control group. To account for individual learner differences, the study presented the performance of the sample data across five quantiles.

3.2 Samples

Since the admission scores of majors within a specific province at the same university are relatively concentrated, students share high similarity in learning abilities, environments, and

TABLE 1 Blended college English teaching design.

Teaching steps	Learning content and arrangement		Learning environment
Resource construction	Teachers	Combine students' characteristics and requirements, reasonably allocate and integrate learning resources	Classroom interviews, WeChat group, and communication
	Students	Cooperate with teachers and participate in resource construction	
Pre-class self-study	Teachers	Publish a task list, provide self-learning tasks, and clarify teaching objectives, emphasis and difficult points	Self-built teaching platform and U campus
	Students	Complete online self-learning tasks and submit questions or difficulties encountered in the learning process	
Face-to-face instruction	Teachers	Complete the teaching design according to the data on the platform, and conduct classroom Q&A and intervention	Smart classrooms
	Students	Conduct various learning activities such as discussion and group collaboration to realize in-depth learning	
Learning assessment	Teachers	Design course assessment scales and provide timely feedback	Self-built teaching platform, Grading Network, and Tencent Classroom
	Students	Complete assignments, exercises, tests, etc., and accomplish self-evaluation and peer assessment	



demographic characteristics. To mitigate endogenous system risk, this study screened a sample of learners from the same major at the provincial normal university. The sample data then underwent additional screening, excluding learners who failed the CET4 exam or did not participate in the CET6 exam. Finally, a valid sample of 676 learners was established, comprising 363 learners in the experimental group for blended teaching intervention and 313 learners in the control group receiving traditional teaching.

Both groups of students were admitted in School of Education and had already received formal English education in high school, having completed their first semester of college English learning. Prior to the intervention, both groups of students had recently taken the CET4 exam. Following the 18-week blended teaching intervention, the students took the CET6 exam in June of the same year.

To ensure the homogeneity of the samples, SPSS was applied to calculate the mean value and variance of samples' demographic variables, such as age, gender, and high school major (arts and science). Additionally, variables such as English scores in the college entrance examination, English test scores at the end of the first semester, as well as the samples' CET4 test scores in reading,

listening, writing were also compared. The results indicated that there was no significant difference between the two groups and the samples had random characteristics, as illustrated in Table 2.

3.3 Instruments

The CET4 (College English Test Band 4) and CET6 (College English Test Band 6) tests were utilized as language proficiency assessments, with the former representing the pre-experiment evaluation and the latter representing the post-experiment evaluation. Both tests, which began preparations in late 1986 and were officially implemented in 1987, are national large-scale standardized teaching tests sponsored by the Ministry of Education of China and presided over and implemented by the Chinese Education Examination Institute, the purpose of which is to promote the English teaching in college, objectively and accurately measure students' English proficiency across four dimensions (listening, reading, writing and overall proficiency), and provide services for improving the college English teaching quality. The National CET4 and CET6 Examination Committee is entrusted

TABLE 2 Variable setting and description statistics.

Variable setting	Variable meaning	Experimental group	Control group
		Mean (standard deviation)	Mean (standard deviation)
Response variable Y			
CET6 (Total score)	Post-experiment overall English language proficiency	441.56 (69.21)	408.73 (73.93)
Cet6l (Listening)	Post-experiment English listening ability	142.88 (31.34)	132.41 (32.82)
Cet6r (Reading)	Post-experiment English reading ability	179.80 (16.40)	161.21 (20.34)
Cet6w (Writing)	Post-experiment English writing ability	118.89 (24.34)	115.11 (23.15)
Grouping variable Blend			
Blend	Blended teaching	1	0
CET4 (Total score)	Pre-experiment overall English language proficiency	492.71 (54.82)	494.86 (49.22)
Cet4l (Listening)	Pre-experiment English listening ability	163.64 (22.31)	164.71 (20.36)
Cet4r (Reading)	Pre-experiment English reading ability	179.83 (17.18)	179.78 (14.50)
Cet4w (Writing)	Pre-experiment English writing ability	149.24 (17.47)	150.37 (16.25)
Cgra	English test scores of the first semester	72.46 (7.2)	74.30 (7.09)
Hgra	College entrance examination English score	121.48 (12.7)	122.51 (10.64)
Demographic variables			
Age	Age	19.07 (0.31)	19.06 (0.25)
Art	Major in arts in high school	1.62 (0.49)	1.60 (0.50)
Female	Female	1.77 (0.42)	1.74 (0.45)
Observation N	Sample number	363	313

TABLE 3 Samples' statistical results on five quantiles.

Individual attributes	Experimental group					Control group				
	10	25	50	75	90	10	25	50	75	90
Cet6	354	377	433	506	537.6	308.4	346.5	406	469.5	514.6
Cet6l	103	114	139	175	182.6	91.4	102	132	165	177
Cet6r	162	168	178	187	206	135	147	160	171	188.6
Cet6w	88.4	96	118	140	151	83	98	116	133.5	148
Cet4	432	448	476	535	576	437.4	458	484	520	564
Cet4l	140	145	157	180	197	141	148.5	160	176	196
Cet4r	160	168	176	186	204.6	163	173	177	184	199.6
Cet4w	130	134	143	167	175	132	136	147	165	173

by the Ministry of Education to be responsible for the design, organization, management and implementation of the tests.

The tests are held twice a year, once in June and the other in December (the time varies slightly every year). CET4 subjects are required to be undergraduate or graduate students in college and those who have passed CET4 (Score is or above 425 points) are approved to apply for CET6.

For both tests, the total score is 710 points. The objective questions of the tests are graded by the computer marking system while the subjective ones are rated by personnel designated by the National CET4 and CET6 Examination Committee with reference to the provided specific grading scales. As required, each graded

test paper is checked by two other raters to guarantee score fairness and validity.

3.4 Model setting

We performed a significance test for the overall regression equation, that is, the F -test, and found that at the significance level of 0.01, the p -value of these four regression models was much <0.01 . Based on the findings, we believe that the regression equation is significant and the regression relationship is valid. Based on the aforementioned analysis, the subsequent linear regression

equation was formulated to study the correlation between blended teaching and English language proficiency:

$$\log(Y_i) = \alpha + \beta \text{Blend}_i + \delta \log(\text{Aca}_i) + \phi \text{Demo}_i + \varepsilon_i \quad (1)$$

Among the variables, *log* represents natural *logarithm* and α is the regression constant, while Y_i denotes the English language proficiency of individual i after the implementation of blended teaching. *Blend* refers to a dummy variable, “1” indicates participation in blended teaching and “0” indicates participation in traditional teaching. The coefficient β associated with the variable “*Blend*” captures the impact of blended teaching on English language acquisition and is hypothesized to have a positive effect. After adjusting for the common linear influence of Blend_i and other predictors on the response variable, for each unit change in Blend_i , the average increase of the response variable is β , that is, “all other conditions being equal, the English proficiency of the experimental group in the later stage is higher than that of the control group by β units.” To account for potential confounding factors that may influence English language proficiency besides blended teaching, the study incorporates two fundamental index systems, namely *Aca* and *Demo*, to refer to academic performance and demographic characteristics, respectively. These index systems serve as vector groups that may contribute positively to English language proficiency in the later stages, independent of the effects of blended teaching. δ and ϕ denote the regression coefficient vector groups of the pre-experiment academic performance and demographic characteristics, respectively. ε_i indicates errors and is used to absorb the effects of unobservable effects and missing variables.

We took the natural logarithm of pre- and post-experimental English proficiency for the following reasons.

Firstly, the practical post-experiment English proficiency data was unevenly distributed. Therefore, we took a natural logarithm to make it closer to a normal distribution without changing the nature and correlation of the data. This would better meet the assumptions of the linear model, improving the accuracy and reliability of the regression analysis.

Secondly, in regression analysis, we usually assume a linear relationship between the independent and dependent variables, and assume that the error term follows a normal distribution. Due to the large span of English proficiency in the later stage of the experiment, the error term is prone to heteroscedasticity, because the variance of the error term is related to the value of the dependent variable. Taking the natural logarithm of post-experiment English proficiency helps to eliminate heteroscedasticity.

Thirdly, the pre- and post-experiment English proficiency is not in a simple linear relationship. If we consider a simple linear relationship without taking natural logarithms, the regression coefficient δ is interpreted as “for every unit increase of pre-experiment English proficiency, the average post-experiment English proficiency rises by δ unit;” If we take the natural logarithm of both pre- and post-experiment English proficiency at the same time, the regression coefficient can be interpreted as “for every 1%

of increase in pre-experiment English proficiency, the average post-experiment English proficiency rises by δ %.” In comparison, the second explanation is more reasonable.

As a form of mean regression, Equation (1) represented the effect of the grouping variable *Blend* on the conditional expectation $E(Y|\text{Blend})$ of English proficiency level. However, due to substantial variations among individual learners, such as their distinct learning and cognitive abilities, Equation (1) solely provides a single indicator of the central tendency. It fails to capture the overall nature of the entire conditional distribution ($Y|\text{Blend}$). To address this limitation, we have incorporated quantile components into Equation (1) based on the research conducted by Koenker (2004) and Bera et al. (2016), who introduced a new methodology by incorporating quantile into regression to investigate the effect of training on economic majors across varying levels. This modification is essential, because it enables us to divide students into five different proficiency levels based on the quantile and establish a conditional quantile model, so as to facilitate an examination of the impact of blended learning on learners across different language proficiency.

$$\log(Y_i^\tau) = \alpha + \beta \text{Blend}_i^\tau + \delta \log(\text{Aca}_i^\tau) + \phi \text{Demo}_i^\tau + \varepsilon_i \quad (2)$$

In Equation (2), *log* represents natural logarithm and τ denotes the quantile point and Y_i^τ indicates the English proficiency of the individual i at the quantile τ in the later stage of the experiment. The coefficient β preceding the grouping variable Blend_i^τ signifies the impact of the blended teaching intervention on individual i at the quantile τ and is assumed to be positive.

Recognizing the disparate statistical scales of each indicator variable, this study employs the Log-Likelihood method to study the variations in learners’ English proficiency across four dimensions, because it enables backward inference of model parameters by observing limited sample information when model distribution is assumed to be normal.

It’s worth noting that we have made the following two basic assumptions about formula (1) and formula (2) to ensure the model was correct and our analysis was reasonable: One was the assumption of random disturbance. It was assumed that ε_i was zero-mean, homovariance, unrelated to sequences, and followed a normal distribution. The other was the assumption that the explanatory variables were non-random.

3.5 Data collection

Upon obtaining consent from the individual students and Student Status Management Department of the school, data and information pertaining to the students’ learning process were collected. A cross-sectional panel was subsequently established, including various demographic variables, such as age, gender, and high school major (arts and science). Additionally, variables such as English scores in the college entrance examination, English test scores at the end of the first semester, as well as listening, reading, writing, and total scores in CET4 and CET6 were also included. The mean value and variance of the variables were compared by SPSS to guarantee the homogeneity of the samples.

TABLE 4 The overall effect of blended English teaching.

Variables	Cet6	Cet6r	Cet6l	Cet6w
Blend	0.091920	0.116982	0.100017	0.043945
	(0.000000)	(0.000000)	(0.000000)	(0.000000)
Variable control	Yes	Yes	Yes	Yes
Observation <i>N</i>	676	676	676	676
<i>R</i> ²	0.941	0.884	0.879	0.891

3.6 Data analysis

Based on the collected data, R 3.6.1 and R Studio were employed to conduct multiple linear regression and conditional quantile models, so as to assess the impact of blended teaching on different language proficiency groups across four dimensions: listening, reading, writing, and overall language proficiency.

Utilizing Equation (1), by conducting a comparison of CET6 scores across different proficiency groups, it was noted that the experimental group displayed relatively higher mean values for various indicators when compared to the control group. As indicated in Table 4, the regression results reveal that the estimated coefficients align with the theoretical expectations and blended teaching accounts for over 88% of the variation in English scores among the samples.

The plotted PDFs presented in Figure 1A indicate that the distribution of CET6 test scores in the control group gradually conforms to a normal distribution, whereas the experimental group exhibits a distinct skewed distribution, which fails to satisfy the prerequisites of normality. Upon assessing the CDFs in Figure 1B, it becomes evident that, at the lower and intermediate levels, the results of students in the experimental group deviate toward the right of those in the control group, indicating a slight superiority of the experimental group at these points.

To account for individual learner differences, the study presents the performance of the sample data across five quantiles. Table 3 illustrates that before the blended intervention, the difference in CET4 scores between the two groups is not statistically significant. However, after the experiment, the CET6 test scores in the experimental group consistently surpassed those of the control group across all five quantiles, albeit with a smaller change in the difference compared to the mean value.

To examine the impact boundaries of blended teaching, Equation (2) is employed to conduct a regression analysis on the scores of the two groups, which were distributed across the 5–95th percentiles. The obtained results were then subjected to linear fitting, yielding the distribution curve representing the effect of blended teaching across the entire sample interval, as illustrated in Figure 2. Results showcase a distinct pattern in the effect of blended teaching, characterized by a higher impact at lower language proficiency levels and a diminishing trend as proficiency increases in the domains of reading, listening, writing, and overall English proficiency. These findings align with the estimates presented in Table 5, which demonstrate the effects of blended teaching across the five quintiles.

4 Results

4.1 Measurement of blended teaching effectiveness based on English grades

Utilizing Equation (1), the Cet6, Cet6r, Cet6l, and Cet6w scores were employed as response variables to control pre-experiment English ability and demographic variables. This allowed for the measurement of the impact of blended teaching on English acquisition. The regression results for the primary indicators are presented in Table 4, showcasing good properties. Firstly, the estimated coefficients align with the theoretical expectations, affirming the reliability of the regression results. Secondly, the goodness-of-fit ranges from 0.88 to 0.94, indicating that this approach accounts for over 88% of the variation in English scores among the samples.

The *t*-test on the regression coefficient indicated that at the significance level of 0.01, if the obtained *p*-value of the regression coefficient was <0.01, the regression coefficient was significant. The *p*-value is reflected in the third row of Tables 4, 5.

According to the regression results, the coefficient of influence for blended teaching on the overall English proficiency is 9.2%, and it is statistically significant at the 0.01 significance level. This implies that, after accounting for all variables that impact English scores, blended teaching can enhance learners' overall English proficiency by 9.2%. Additionally, blended teaching demonstrates positive performance across the three main decomposable indicators of English: reading, listening, and writing. Notably, blended teaching has the greatest impact on reading, with an increase of 11.7%. It also contributes to a 10.0% improvement in listening skills, while the effect on writing is comparatively low at 4.4%. Evidently, from the perspective of academic achievement, when compared to traditional teaching methods, blended teaching exhibits the ability to comprehensively enhance learners' English language proficiency and improve the efficiency of English acquisition.

4.2 Decomposition of teaching effect based on learner differences

For the purpose of appraising the impact boundaries of blended teaching, Equation (2) is employed to conduct a decomposition of the blended teaching effect, factoring in the individual variances among learners. The regression findings, as presented in Table 5, demonstrate that blended teaching exerts a positive influence on the acquisition of English and its decomposable indicators. However, it is noteworthy that the overall effectiveness of blended teaching diminishes progressively as the quantiles increase.

In a comparison across different proficiency level groups, it is evident that blended teaching yielded the most optimal outcomes within the low-level group (10th percentile). Students in this group exhibited notable improvements in their overall, reading, listening, and writing skills, with increases of 12.4, 13.5, 13.1, and 7.0% respectively, when compared to their counterparts undergoing traditional classroom learning at the same language proficiency level. While the teaching incentive effect on the medium-low level group (25th percentile) weakened to ~11.0% in comparison to the

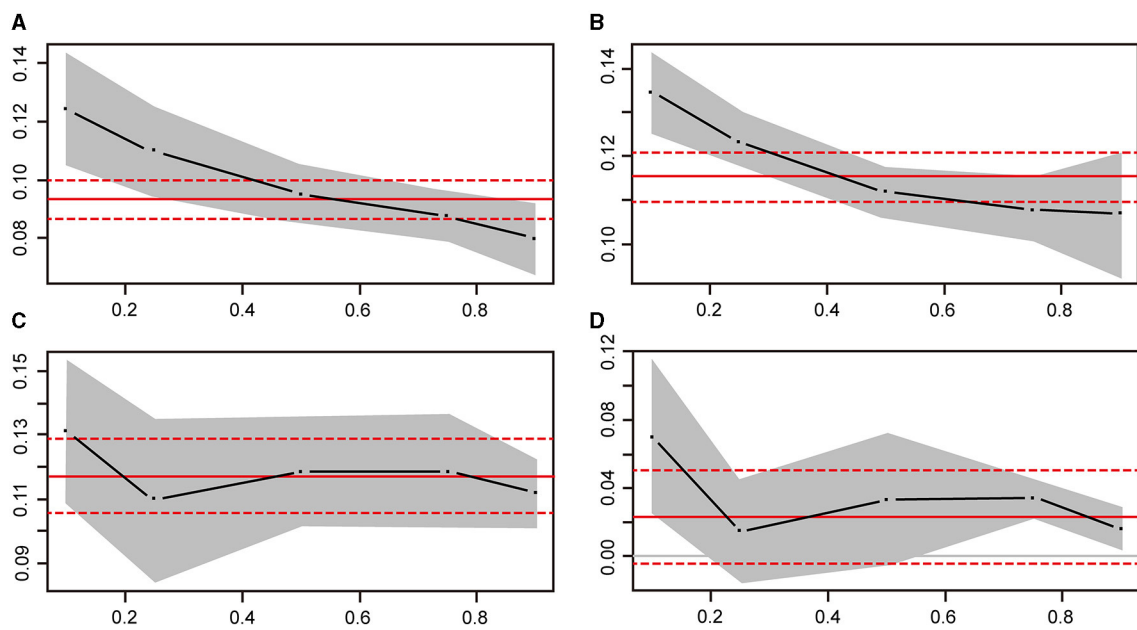


FIGURE 2 Distribution curve of blended English teaching effect across the entire sample interval. **(A)** Distribution curve of blended teaching effect on overall English proficiency across the entire sample interval. **(B)** Distribution curve of blended teaching effect on reading across the entire sample interval. **(C)** Distribution curve of blended teaching effect on listening across the entire sample interval. **(D)** Distribution curve of blended teaching effect on writing across the entire sample interval.

TABLE 5 The effect of blended teaching on five quantiles.

Variables	QR10	QR25	QR50	QR75	QR90
Blend	0.1239131	0.1097167	0.09513309	0.087662916	0.07985506
	0.00	0.00000	0.00000	0.00000	0.00000
Blended reading	0.134625	0.1233569	0.1118855	0.1078723	0.1068209
	0.00049	0.00005	0.00000	0.00007	0.00073
Blended listening	0.1309566	0.1096343	0.1186565	0.1185552	0.1117980
	0.00000	0.00000	0.00000	0.00000	0.00000
Blended writing	0.07023774	0.01514778	0.03324325	0.03470228	0.01605487
	0.01062	0.0001	0.02084	0.40499	0.13250
Variable control	Yes	Yes	Yes	Yes	Yes
Observation N	676	676	676	676	676

low-level group, all indicators remained statistically significant at the 0.01 significance level. This suggests that the acceptance of blended teaching among medium-low level students is also deemed satisfactory. In the case of the medium-high level group (75th percentile) and high-level group (90th percentile), blended teaching demonstrates significant enhancements in reading and listening proficiency for both groups. In terms of writing ability, at the low and medium-low level, blended teaching significantly improves students' writing capability. However, at the intermediate, medium-high and high level, blended teaching impact fails to meet the statistical significance, indicating that blended teaching has little impact on writing proficiency of students with a high language proficiency. In addition, the overall achievement impact exhibits a

gradual decline, with the high-level group experiencing a minimal impact of 8.0%.

In terms of English decomposable indicators, the impact of blended teaching on the acquisition of reading and listening skills is particularly pronounced. The efficiency of blended reading teaching ranges from 10.7 to 13.5%, while the efficiency of listening teaching ranges between 11.0 and 13.1%. Both of these effects are statistically significant at the 0.01 level. Conversely, the influence of blended teaching on writing skills is more intricate, exhibiting irregular fluctuations across different quantiles. Specifically, at the 10, 25, and 50th percentiles, the rewards are 7.0, 1.5, and 3.3%, respectively. These effects are statistically significant at the 0.01 level, but they do not reach statistical significance at the 75 and 90th

percentiles. The coefficient of the blended teaching factor *Blend* is not significant, indicating a minimal impact on writing ability.

It's not difficult to find that the impact of blended teaching on writing performance is limited and irregular across five quantiles. This is due to the fact that for high-level learners, basic knowledge such as vocabulary and grammar, have already been acquired. However, their absorption and mastery of advanced writing knowledge is not enough, so the extent of improvement is not as expected. It can be inferred that this new teaching mode mainly plays the role of knowledge consolidation rather than the mastery and transfer of language knowledge.

4.3 Interval distribution of blended teaching effects across five quantiles

By employing Equation (2), and taking the unit of 1%, a regression analysis was conducted on the language scores of the two groups, which were distributed across the 5–95th percentiles. The obtained results were then subjected to linear fitting, yielding the distribution curve representing the effect of blended teaching across the entire sample interval (Figure 2). The average teaching effect, as estimated by Equation (1), is depicted by the dotted line. If the difference curve lies above the estimated value, it indicates that the effect of blended teaching on the respective quantile surpasses the average. Conversely, if the difference curve falls below the estimated value, it signifies that the effect is below average.

Figure 2 reveals a distinct pattern in the effect of blended teaching, characterized by a higher impact at lower language proficiency levels and a diminishing trend as proficiency increases in the domains of reading, listening, writing, and overall English proficiency. This observation suggests that learners with lower English language proficiency benefit the most from blended teaching, while the impact on high-level learners is notably limited. These findings align with the estimates presented in Table 5, which demonstrate the effects of blended teaching across the five quantiles.

In relation to the overall language proficiency (Figure 2A), it is worth noting that the inflection point of the effectiveness curve is observed at the 49th percentile, beyond which the rewards of blended teaching fall below the average level. This implies that students with intermediate and lower proficiency levels tend to benefit more from blended teaching compared to those with medium-high and advanced academic levels.

Based on the observations from Figure 2B, it is evident that the impact coefficient of blended teaching on reading skills remains consistently high within the 5–30th percentiles. However, between the 40 and 90th percentiles, the impact coefficient goes downward and falls below the average level. This suggests that the influence of blended teaching on students with intermediate and high reading proficiency decelerates, while its impact on students with advanced reading ability is minimal.

According to Figure 2C, the impact of blended teaching on listening skills maintains a high level within the 5–20th percentiles. It exhibits a “U” shaped movement between the 20 and 50th percentiles, indicating a relatively stable effect. In addition, there is a consistent and stable impact between the 50 and 75th percentiles. However, beyond the 75th percentile, the impact coefficient goes

continuously downward below the average level. These findings suggest that blended teaching has a significant positive effect on students with lower listening ability, while its impact on students with higher listening ability is relatively modest.

According to Figure 2D, the impact of blended teaching on students' writing performance exhibits a more pronounced pattern. Notably, an inverted “U” trend is observed, with the influence coefficient surpassing the average level between the 40 and 75th percentiles. This suggests that the blended teaching mode has a positive and effective impact on students with intermediate to medium-high levels of writing ability, promoting their writing skills.

5 Discussion

The research on the effectiveness of EFL (English as a foreign language) blended teaching is of great significance in the university's adoption and widespread implementation of this innovative teaching approach. Within this domain, scholars have primarily focused on the feedback and teaching quality associated with blended teaching, while relatively neglecting the development of college students' foreign language proficiency within the blended teaching context, as well as the variations in acceptance and rewards of blended teaching across different language proficiency groups. To address this gap, this study leverages micro data from a provincial normal university's blended English teaching program. This is the first time when samples' demographic characteristics and prior academic performance are formally evaluated for investigation in this domain. Besides, this study introduces a new methodology by employing multiple linear regression and conditional quantile models to assess the impact of blended teaching. This methodology not only enables us to examine the overall impact of blended teaching, but also allows assessment of its effect on different proficiency groups, helping to identify its effectiveness on individual learners across four dimensions.

Due to the generality of the CET across the country and its equitable scoring system, CET 4 and CET 6 have been adopted as primary indicators to assess language proficiency before and after the blended teaching intervention. By combining the data presented in Tables 2, 3, the impact of blended teaching on EFL is discussed.

5.1 The efficiency and fairness of blended teaching

From the standpoint of overall language acquisition growth rate, the efficacy of blended teaching in college English ranges from 8.0 to 12.4%, with an average of 9.2%. This result verifies findings of López-Pérez et al. (2011), Ige and Hlalele (2017), Jiang and Hu (2018), and Lv (2021), suggesting that the implementation of this novel teaching approach enhances English proficiency across all proficiency levels, surpassing the efficiency of traditional teaching methods. However, upon integrating the results of conditional quantile regression and the distribution curve depicting the teaching effect, it becomes apparent that the heightened efficiency of blended teaching primarily stems from significant

advancements observed among the experimental groups whose English proficiency falls within or below the intermediate level (CET4 scores below 512 points). This result is incongruous with the study by [Fakhir and Ibrahim \(2018\)](#), [Oweis \(2018\)](#), [Nazzal and Alradi \(2020\)](#), who maintained that all college students who received blended teaching exhibited a moderate enhancement in their English scores. Evidently, this study results show that learners who have already attained a medium-high to high level of proficiency (CET 4 scores above 550 points) have made minimal contributions to the blended teaching effect. The disparity might stem from different study methods, because Oweis, Fakhir and Ibrahim, Nazzal and Alradi's studies only measured the overall impact of blending teaching by comparing the mean values of the two groups, failing to examine the impact on different proficiency groups. From the perspective of academic performance promotion, this new teaching mode mainly plays the role of knowledge consolidation, and its impact still stays at the level of basic knowledge cognition, that is, memory and understanding, rather than the deep integration and transfer of language knowledge and ability. This explains why the results are radically different from previous investigation by [Kwak et al. \(2015\)](#) and [Gao \(2021\)](#), who claimed that blended teaching had either or no effect on the learning process. The result difference derives from using of different sample populations. In their study, the samples have already acquired higher language proficiency, hence they only achieved marginal language improvement from this teaching mode. This indicates that blended teaching only solves the simple problems of basic learning, and has limited effect on deep knowledge processing and transfer.

The findings of this study shed light on the difference between theoretical and empirical evidence in previous research on the effectiveness of blended foreign language teaching. Prior research, often designed based on school-specific principles and lacking comprehensive macro-level reference standards, has yielded less-than-ideal results when appraising the overall language proficiency of high-level subjects in blended teaching; Conversely, significant improvements in academic performance are observed when the research focuses on learners below this proficiency threshold.

It can be inferred that blended teaching serves as a means to regulate classroom teaching and address learning disparities. While it effectively reduces the performance gap among learners, this effect primarily comes at the expense of impeding the learning progress and opportunities of individuals with medium-high or high language proficiency. Therefore, the advantages of personalized learning fail to be adequately emphasized by blended teaching. In the future, more time and effort need to be invested to delve into English teaching design to improve blended teaching effectiveness for students with medium-high level of proficiency.

Factoring in the variations in college admission policies, it is often observed that freshmen admitted to higher-level universities possess a higher level of foreign language proficiency compared to those admitted to local colleges. Therefore, when considering the broader context of higher education, it becomes evident that while many universities are implementing or exploring blended teaching for public English basic courses, this teaching approach may not be universally applicable for all institutions seeking to enhance students' English acquisition efficiency. College English blended teaching should be designed and implemented in accordance with

students' language knowledge and capabilities. Teachers need to keep students' proficiency disparity in mind and constantly adjust teaching content, activities and evaluation to meet the needs of students of different language levels.

5.2 Differences in English acquisition in blended teaching

The decomposition effect analysis of blended teaching reveals a notable enhancement in learners' reading proficiency compared to traditional teaching methods. This finding suggests that blended teaching has not changed the reading-centered learning preferences of learners. In fact, this observation can be attributed to the task design inherent in blended teaching. Within a blended classroom, learners are required to independently engage with course content and fulfill predetermined learning tasks. Therefore, learners are compelled to actively gather, organize, and present English materials on various topics, thereby significantly intensifying and broadening their reading experiences. This heightened reading intensity eventually contributes to the improvement of learners' reading abilities.

The study revealed a consistent 11% stability in the impact of blended teaching on listening skills, verifying the study results of [Hou \(2010\)](#) and [Liu \(2016\)](#). According to [Skehan's \(1998\)](#) theory, the result suggests that the majority of learners are still in the early stages of English acquisition, undergoing a steady growth, and haven't reached the threshold of advanced learning, thereby benefiting a lot from blended teaching.

In addition, the influence of blended teaching on writing proficiency demonstrates variability, percentiles, the rewards are 7.0, 1.5, and 3.3%, respectively. This result contradicts the conclusion of [Hou \(2010\)](#), who found that blended teaching modality failed to enhance students' writing skills. This discrepancy can be attributed to the circumstance that intermediate and low-level learners obtain advantages from the enhancement of fundamental skills, such as vocabulary and grammar, within the framework of blended teaching. Conversely, high-level learners may have already attained a comprehensive grasp of these foundational elements, yet their assimilation and mastery of advanced writing knowledge remain inadequate. As a result, the anticipated improvement falls short of expectations. This finding aligns with the findings of [Jiao et al. \(2017\)](#) in their study on college English writing utilizing the ICLASS platform. Their research revealed notable disparities in scores between the experimental and control groups in the domain of applied writing, which emphasized adherence to format and norms. However, no significant differences were observed in argumentative essay writing, which emphasized advanced skills such as logical coherence and argumentation skills.

From a cognitive perspective, reading involves the assimilation and processing of fundamental concepts such as vocabulary, grammar, and logic. On the other hand, listening and writing entail a more profound understanding and comprehensive application of this linguistic knowledge. The findings of this study indicate that students benefit the most from blended teaching in reading. Therefore, based on [Anderson et al.'s \(2000\)](#) interpretations, in

terms of promoting academic achievement, blended teaching primarily serves the purpose of consolidating knowledge. Its impact remains predominantly at the level of basic knowledge cognition, specifically memory and understanding, rather than facilitating a deeper understanding and transfer of language knowledge, although blended teaching was originally intended to enhance learners' initiative and improve their efficiency in higher-order learning (Dawson, 2015).

In the case of universities where freshmen already possess a high level of English proficiency, a blended teaching approach focused solely on grammar and vocabulary cognition may no longer be effective. Instead, blended practice should extend beyond general English and incorporate more advanced academic knowledge and specialized backgrounds. Additionally, careful attention should be given to the selection of teaching materials and curriculum design to ensure that these students are provided with ample opportunities for language learning and further growth. For students with lower English proficiency and less initiative, blended teaching design should start from the basic language knowledge, stressing basic cognition, such as English memory, understanding and application, and then gradually proceed to promote their advanced cognitive ability, such as analysis, evaluation, and creativity.

Meanwhile, the findings underscore the prevailing teaching reality, wherein Chinese students at the primary and intermediate levels of English learning face a pronounced lack of listening training. Therefore, teachers need to promote students' listening capability by imparting listening skills and increasing practical training, so as to help them achieve a higher level of listening proficiency. In addition, it is advisable for teachers to pay attention to the cultivation of students' learning autonomy and enhancement of their initiative. There is a call for future studies to emphasize the purpose of personalized teaching by investigating into pedagogical design, so as to cater to the needs of students with various English proficiency.

6 Limitations

It's worth noting that this study explores the learning effect of blended teaching from the perspective of test data analysis, and does not cover relevant factors such as teachers' and students' learning initiative, which should be covered by the follow-up research to explore the effect of blended teaching in college English more comprehensively. What's more, this study fails to provide specific pedagogical methods or teaching designs to help students with higher English proficiency benefit more from this teaching mode, which should be paid more attention to in future study.

7 Conclusion

This study introduces a new methodology by employing multiple linear regression and conditional quantile models to assess the impact of blended teaching. This methodology not only enables us to examine the overall impact of blended teaching, but also allows assessment of its effect on different proficiency groups, helping to identify its effectiveness on individual learners across four dimensions. The conclusions of this study are as

follows: Firstly, blended teaching demonstrates the potential to enhance the overall effectiveness of college English teaching and significantly improve students' EFL efficiency. Secondly, the effectiveness of blended teaching primarily manifests in the substantial improvement of language acquisition efficiency among groups with intermediate or lower English language proficiency levels (CET 4 scores at or below 512 points), while its impact on medium-high and high-level proficiency groups (CET 4 scores at or above 550 points) is comparatively less pronounced. Thirdly, the influence pathway of blended teaching on college students' EFL follows a descending order of reading, listening, and writing, suggesting that the blended teaching approach still exhibits a bias toward the memorization and acquisition of foundational knowledge (such as vocabulary and basic grammar), with limited impact on the in-depth comprehension and transformation of language knowledge.

In the future, effort will be made to incorporate more relevant factors such as teachers' and students' learning initiative into the investigation, so as to obtain a more comprehensive assessment of the impact in EFL blended teaching. Meanwhile, pedagogical research will focus on the blended teaching design for students with higher English proficiency to ensure their benefits from this teaching mode.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of Air Force Aviation University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YT: Conceptualization, Formal analysis, Methodology, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. LY: Conceptualization, Formal analysis, Resources, Software, Validation, Visualization, Writing – review & editing. LL: Conceptualization, Investigation, Validation, Writing – review & editing. HZ: Investigation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

We would like to acknowledge the reviewers for their helpful comments on this paper.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1264573/full#supplementary-material>

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