

# Examining the Impact of Blended Learning on Test Scores: A Statistical Analysis Using an ANOVA Model

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**Abstract:** Blended learning has gained popularity due to its unique teaching methods and integration of information technology. The increasing interest in blended learning and the need to evaluate its impact on student outcomes serve as the driving forces for this study. In order to examine the effectiveness of blended learning, the authors have chosen the analysis of variance (ANOVA) method as the analytical framework based on its suitability for comparing means across different groups and identifying significant factors that influence test scores. The results of the study indicate that test scores are significantly impacted by blended learning.

## 1. Background

With the rapid development and popularization of information technology, the field of education is also facing great changes and challenges. The traditional teaching mode can no longer meet the needs of students' personalized learning and sharing of educational resources. In order to adapt to this change, the education sector has begun to explore new teaching models, of which the most promising is the blended teaching model.[8]

Blended teaching mode is a teaching method that combines online independent learning and face-to-face teacher guidance. It makes full use of the advantages of information technology to liberate learning from traditional classroom constraints so that students can learn independently online according to their own learning progress and interests. At the same time, teachers can pay more attention to students' learning in face-to-face teaching and provide personalized guidance and support. The goal of the blended teaching model is to improve students' learning effectiveness and motivation through technology enhancement and student-centered teaching methods.[3]

In the field of English teaching, blended teaching mode has become a major direction of teaching reform. Traditional English teaching mainly focuses on the inculcation of language knowledge and the training of test-taking skills, neglecting the enhancement of students' comprehensive application ability and intercultural communication ability. The blended teaching mode can better cultivate students' comprehensive application of English and cross-cultural communication skills. Through online learning, students can have access to more learning resources and real language environment to improve their listening, speaking, reading and writing skills. Through face-to-face teaching, students can have real-time

interaction and communication with teachers and classmates to improve their oral expression and cross-cultural communication skills.

This study tests the relevance of blended learning's impact on English performance using the Comprehensive English course as an example. It also offers theoretical justification for the blended learning model's widespread implementation.

## 2. Blended Learning model

The information technology-supported blended education model focuses on action research, combines teaching with learning and learning with doing, actively incorporates "collaborative" and "discussion-based" instructional design, and integrates online and offline teaching resources.[7] This model adopts real-time monitoring and multi-dimensional assessment to improve students' participation and learning effectiveness. As shown in Table 1, the model accomplishes online knowledge transfer through educational preparation before class, internalization of knowledge through instructional design during class, and consolidation and extension through multidimensional evaluation after class to further consolidate learning content.

In the blended education model supported by information technology, independent learning before class is one of the main ways of knowledge acquisition. [9] Learners are able to combine existing knowledge to understand and absorb information, and construct a knowledge system independently. And in the classroom, through a series of teaching activities, learners are able to apply and expand the content of the knowledge they have mastered before class, and improve their ability to construct a knowledge system in classroom activities. In addition, the combination of formative evaluation and process evaluation after class, and the combination of

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teacher-student evaluation and student-student evaluation further consolidate and deepen the learning effect.[5]

Throughout the IT-supported blended education process, learners' capacity building is fully realized. Learners develop independent learning skills through independent use of resources, while the improvement of communication and collaboration skills is mainly realized through cooperative inquiry, online discussion and other interactive activities in the classroom. The blended education model focuses not only on the transfer of knowledge, but also on the cultivation and enhancement of competencies to meet the demand for talents in modern society.[1]

In addition, the model also focuses on learners' emotional experience and motivation mechanism, creating a positive learning environment. Assessment feedback is provided throughout the blended learning process to ensure objective evaluation of learners' learning effects.[6] The multidimensional assessment method combines process and summative assessment, as well as an assessment system that integrates intra-group, inter-group and teacher assessment.

The innovation of the model is the construction of an intelligent teaching platform that integrates online and

offline teaching resources. Through real-time monitoring and multi-dimensional assessment, the model not only focuses on the transmission of knowledge, but also on the cultivation and improvement of abilities to meet the demand for talents in modern society.[2] At the same time, the model also provides an active, interactive and interesting learning environment, which helps to cultivate learners' independent learning ability and higher-order thinking. As shown in Table 1, the core of the model is to cultivate students' independent learning ability and higher-order thinking and to realize accurate teaching.

For the teaching experiment, the author chose two administration classes of second-year computer science majors from a university in eastern Guangdong to assess the instructional impact of blended learning to regular classroom instruction. With 41 students in Class 1 of Grade 20, the experimental group was compared to 43 students in Class 2 of Grade 20 as the control group. There was little variation in the general level and skill of the 84 students. The experimental group used blended learning, which divides instruction into three phases: before, during, and after class. The control group continued to use the standard classroom teaching approach.[4]

**Table 1** Blended Teaching Model

Teaching Preparation	Analysis of the learning situation		
	Network resource selection		
	Instructional design		
Teaching Design	Before class	Self-directed learning	Web-based learning resources
		Group assignment	Group study and discussion
	During class	Pre-learning feedback	Review key points and answer questions
		Share and exchange	Personalized analysis of key points
		Presentation of the results	Communication, discussion and intergroup evaluation
		Class summary	Wrap-up reflection
	After class	Assignment	Reinforcement of learning content
		Discussion	Outline questions and answers
Teaching Evaluation	Formative evaluation		Summative evaluation
	Online self-directed learning performance		Unit test
	Team work		Results show
	Classroom discussion		Assignment grades

### 3.Variance model analysis

Numerous elements influence the assessment index of certain products that are currently in production. ANOVA is the method used to identify the elements that significantly affect a product by conducting tests and analyzing the data to determine which factors have an impact on the product.

#### 3.1. Example

Assume that the general examination results of the first semester final exam are  $y$ , and the English test scores of the  $m$  classes taking part in the experiment are  $x$ . In the first semester final test, where  $(i=1,2,\dots, m; j=1,2,\dots,n_i)$  represents the English scores of the  $j$ th student in class  $I$  and  $Y_{ij}$  represents the general examination scores of the

$j$ th student in class  $I$ . For  $m$  teaching classes, the blended learning model's efficacy is assessed.

#### 3.2.Variance model analysis

$Y_{ij}$  and  $X_{ij}$  are closely related. In this case, there are two factors: the teacher, which is referred to as the variance variable because it is a qualitative factor. The second is a quantitative variable known as a covariate,  $X_{ij}$ .

$$y_{ij} = \mu + \alpha_i + \gamma x_{ij} + \varepsilon_{ij}, \quad (i=1,2,\dots,m; j=1,2,\dots,n_i)$$

where  $\alpha$  is the effectiveness of class  $i$  and satisfies  $\sum_{i=1}^m \alpha_i = 0$ ,

$\varepsilon_{ij}$  is the random error, and  $\gamma$  is the regression coefficient.

### 3.3. Parameter estimation of the model

The least squares estimation (LSE) of the unknown parameters in (1) is  $\hat{\mu} = \bar{y}$ ,  $\alpha_i = \bar{y}_i - \bar{y}$ ,  $\hat{\gamma} = \frac{S_{yxw}}{S_{xxw}}$

### 3.4. Hypothesis testing of the model

Let us now investigate whether there is a significant

difference in teaching effectiveness ( $\alpha_i$ ) among the  $m$  teaching courses in model (1). The examination of teaching effectiveness is only performed when there is a significant difference in teaching effectiveness among the  $m$  teaching classes. Model (1)'s hypothesis test is identified as.

Examine the  $H_0: \alpha_i=0, (i=1,2,\dots,m)$

$$F = \frac{R_A / (m-1)}{R_W / (n-m-1)} \sim F(m-1, n-m-1),$$

For the convenience of calculation, the data are presented in the form of Table 2 for data analysis

**Table 2** Test table for the analysis of covariance model

Source of variance	Modified Sum of Squares	Correction of degrees of freedom	Mean Square	F ratio	Threshold	Significance
between classes	$R_A = R_r - R_W$	$m - 1$	$V_A = \frac{R_A}{m - 1}$	$F_A = \frac{V_A}{V_W}$	$F_\alpha = (m - 1, n - m - 1)$	
In Class	$\frac{R_W = S_{yyw} - \frac{S_{xyw}^2}{S_{xxw}}}{S_{xxw}}$	$n - m - 1$	$V_w = \frac{R_w}{n - m - 1}$			
Total	$\frac{R_T = S_{yyT} - \frac{S_{xyT}^2}{S_{xxT}}}{S_{xxT}}$	$n - 2$				

Of which:  $n = \sum_{i=1}^m n_i$ ,  $\bar{x}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} x_{ij}$ ,  $\bar{y}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} y_{ij}$ ,  $\bar{x} = \frac{1}{n} \sum_{i=1}^m \sum_{j=1}^{n_i} x_{ij}$ ,

$$\bar{y} = \frac{1}{n} \sum_{i=1}^m \sum_{j=1}^{n_i} y_{ij}, S_{xxi} = \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_i)^2, S_{yyi} = \sum_{j=1}^{n_i} (y_{ij} - \bar{y}_i)^2,$$

$$S_{xyi} = \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_i)(y_{ij} - \bar{y}_i), S_{xxT} = \sum_{i=1}^m \sum_{j=1}^{n_i} (x_{ij} - \bar{x})^2,$$

$$S_{yyT} = \sum_{i=1}^m \sum_{j=1}^{n_i} (y_{ij} - \bar{y})^2, S_{xyT} = \sum_{i=1}^m \sum_{j=1}^{n_i} (x_{ij} - \bar{x})(y_{ij} - \bar{y}),$$

$$S_{xxw} = \sum_{i=1}^m S_{xxi}, S_{yyw} = \sum_{i=1}^m S_{yyi}, S_{xyw} = \sum_{i=1}^m S_{xyi}.$$

### 3.5. Linear model for effectiveness of blended instruction

When there is a significant difference in  $\alpha_i$ , the linear model for evaluating teaching effectiveness is constructed using the regression parameter  $\gamma$  in model (1), and because there is an effect of the covariate  $x_{ij}$ , the covariates need to be taken at the same level at the same time[10], that is, the mean of the English Advanced Placement scores of each class  $\bar{y}_i$  minus  $\hat{\gamma}(\bar{x}_i - \bar{x})$ , that is, the estimated value of the regression coefficient  $\gamma$  in (2) to remove the The linear model of the effectiveness of blended instruction after ranking the mean scores after

$$\text{the effect of achievement } x \text{ is } \bar{y}_1' = \bar{y}_1 - \hat{\gamma} (\bar{x}_1 - \bar{x}), (\hat{\gamma} = \frac{S_{xyw}}{S_{xxw}}, i = 1, \dots, m)$$

## 4.Result Analysis

It was found that the test scores of the experimental class were significantly higher than those of the control class, which indicates that the effectiveness of the blended education model in the integrated English program has been significantly improved.

First, by comparing the data of the experimental and control classes, we found that the average score of the experimental class was higher than that of the control class, which is a significant difference. This indicates that the blended education model has stronger effectiveness in enhancing students' learning outcomes. Further analysis showed that the experimental class showed significant improvement in both comprehensive English application skills and intercultural communication skills, which may be attributed to the fact that in blended education, learners had the opportunity to have access to more learning resources before class, which fostered their self-directed learning ability. During the lesson, learners developed their communication and collaboration skills by taking on more group learning and discussion tasks. In the group assessment and student-student mutual assessment at the end of the lesson, learners were stimulated to self-reflection.

Secondly, further analysis found that students' English comprehensive application ability and intercultural communicative competence were significantly improved based on the blended education model. Under the blended teaching mode, the experimental class's English comprehensive application ability and intercultural communicative competence were significantly improved. This may be due to the fact that the IT-supported blended teaching mode realizes the organic integration of online and offline education, thus significantly improving the

learners' English theoretical level and practical application ability. This teaching mode combines traditional face-to-face teaching with online learning, providing learners with more flexible and diversified learning methods. Through the integration of online learning resources and technological means, the blended teaching mode can provide learners with a richer and more personalized learning experience, thus helping to improve their English theoretical level and practical application ability.

Taken together, the application of IT-supported blended teaching mode in comprehensive English courses can significantly improve students' learning outcomes, especially in terms of comprehensive English application skills and cross-cultural communicative competence. The advantage of the blended education model is that it can promote learners' independent learning, interactive communication, and stimulate learners' self-reflection. By relying on the support of information technology, the blended teaching mode realizes the organic integration of online education and offline education, which significantly improves the learners' English theoretical level and practical application skills.

## 5. Conclusion

According to the constructivist theory of knowledge, timely delivery and high-quality education are key components of effective teaching and learning. In order to achieve a higher degree of integration between information technology and classroom instruction, teachers employ both theoretical foundations to incorporate intelligent technology into teaching and learning.

In this research, a linear model for assessing blended learning effectiveness is presented along with formulae and methods for parameter estimation and hypothesis testing. An ANOVA model is also suggested for examining the efficacy of the blended teaching approach. It was concluded that test scores are significantly impacted by blended learning.

Of course, there is still a lot that can be done to improve the blended teaching model. To fully explore the potential of the blended teaching model and to enhance its implementation, it requires the joint efforts and continuous investment of all parties involved, including teachers, schools and students. Specifically, teachers need to master relevant teaching techniques and strategies to optimize and innovate the teaching mode; schools should provide the necessary technical support and resources; and students should actively participate in and adapt to the new learning mode, and jointly promote the improvement and refinement of the teaching mode.

In addition, we also need to note that the implementation effect of the blended teaching mode is affected by many factors, including but not limited to students' learning ability, learning attitude, teachers' teaching level, and schools' resource conditions. Therefore, we need to conduct an in-depth study and assessment of these factors in order to better understand and grasp the actual effects of the blended teaching model

and provide a basis for future teaching improvement.

Overall, the blended teaching mode has great potential and value, and it is worthwhile for us to keep exploring and trying in our future teaching practice. Through continuous improvement and optimization, we are expected to achieve the dual goals of education quality improvement and students' personalized development.

## Funded projects

1. 2023 Guangdong Undergraduate Colleges and Universities Teaching Quality and Teaching Reform Project Construction Project
2. 2023 Higher Education Research Project of Guangdong Higher Education Society "14th Five-Year Plan" (Project No. 23GYB47)
3. 2023 Higher Education Teaching Reform Key Projects of Jiaying University (Project No.: JYJG2023102)
4. "Comprehensive English (IV)", a first-class university-level course of Jiaying University in 2023

## References

- 1 Bloom. New views of the leader: Implications for Instruction and Curriculum. Published at Educational leadership of America .1978:3 ~ 8
- 2 Douglas, C. Montgomery, Design and Analysis of Experiments [M] John Wiley & Sons Inc., U.S.A., 1991:369-385
- 3 He Kekang. How to realize the "deep integration" of information technology and education [J]. Curriculum - Teaching Materials - Teaching Method, 2014 (2).
- 4 Hofmann, J. (2021). Blended Learning Case Study. Learning Circuits, 5(3), 26.
- 5 Lipponen, L. (2022). Exploring Foundations for Computer-Supported Collaborative Learning. In G. Stahl (Ed.), Computer Support for Collaborative Learning (pp.72-81).
- 6 Macdonald, J. (2016). Blended Learning and Online Tutoring. Burlington: Gower Publishing Limited
- 7 Mathur, R. & Oliver, L. (2017). Developing an International Distance Education Program: A Blended Learning Approach, Online Journal of Distance Learning Administration, 10(4)
- 8 Merrill M D. First principles of instruction[J]. Educational Technology: Research and Development,2022,(3):43-59
- 9 Oliver, M., & Trigwell, K. (2015). Can "Blended Learning" Be Redeemed? E-Learning, 2(1), 17-26.
- 10 Yang Wenli. Introduction to Linear Models [M] Beijing: Beijing Normal University Press 1998.166-211