Evaluation of English Writing Teaching Effect with Output-based C2GS2 Model

Tai Yuanyuan*

Department of Foreign Languages, Heze University, Heze 274015, China

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Abstract

An evaluation system for English writing teaching effects with the output-based C^2GS^2 model is established in this study to better understand the teaching status of English writing teaching effects and allow for effective reform and implementation of teaching methods. An evaluation model is constructed for English writing teaching effects, English writing teaching status, and students' learning effects. Qualitative, quantitative, and data envelopment analyses are applied. The C^2GS^2 evaluation model is adopted through teaching example verification and statistical analysis of data. The important function of data envelopment analysis in teaching effect analysis is expounded from different aspects.

Keywords: data envelopment analysis, C^2GS^2 evaluation model, English writing, teaching effect

1 Introduction

Data envelopment analysis (DEA) was first proposed in 1978 [1]. It is a quantitative analysis method that applies linear programming to perform a relatively effective evaluation of comparable units of the same kind according to multiple input indexes and multiple output indexes [2]. DEA extends single input–output in production and the decision-making unit to multi-input and multi-output decision making. It utilizes the method of weighting to comprehensively analyze data and eventually obtain comprehensive conclusions [3]. The first model is the C^2R model. Gradually, another DEA model, C^2GS^2, was developed [4]. This model is employed to study the "technological effectiveness" of production departments. DEA exhibits an absolute advantage in the evaluation of the effectiveness of multi-input and multi-output without the need for dimensionless treatment of data or confirmation of explicit expressions of input and output data [5]. This model can exclude many artificial subjective factors and has strong objectivity. The quantity of samples required is small. Therefore, the model is widely applied.

In accordance with relevant provisions, an evaluation system should reflect the diversity of the subject and the diversification of evaluation forms. The evaluation should focus on the development of students' comprehensive application ability and learning effects [6]. Formative evaluation and summative assessment can be combined to focus on both results and processes so that the evaluation of the learning process and learning result can achieve harmony and unity [7]. However, in practical teaching, the writing scores of students often serve as the evaluation standard of the teaching effect. This condition does not comply with actual situations to some extent and cannot determine the teachers' teaching conditions objectively [8]. Therefore, how to change the traditional teaching evaluation method and cultivate the writing ability in the English learning process is a great problem faced by current English teaching. This study utilizes DEA and regards English writing teaching as an example to set up a model for evaluation research [9].

Currently, most scholars focus on studying DEA. Research achievements are mainly classified into two categories [10]. First, most research achievements are of summative introductions and set forth historical development, model theory, and significance. Such studies are merely static elaborations and lack dynamic research and analysis that combine static and dynamic states. These studies are based on macroscopic exploration, and theoretical support is insufficient. In addition, relevant application specifications are lacking. Second, in studies on the practical application of DEA, most researchers prefer to use empirical analysis in the fields of military, economics, science and technology, and medicine. For example, Zhang Yanli, Li Xianwen, Mao Yanjun, Tian Meimei, Chen Guoliang, Xia Laibao, and Han Zexian studied the applications of the C^2R and C^2GS^2 models in these fields and conducted an empirical analysis of the effectiveness of the models [11]. A general survey of these studies reveals that application fields are limited and the largest values of DEA and relevant theoretical models are not fully maximized. Therefore, further exploration and research are still necessary.

On this basis, the English writing teaching effect is regarded as the object in this study. The model is changed based on traditional DEA. Examples are utilized, and static and dynamic states are combined to evaluate the English writing teaching effect by surveying statistical data. In addition, the effectiveness and preponderant functions of this method are discussed. Reference value and theoretical support are provided to further generalize the Chinese teaching reform, contribute to the understanding of the modern teaching effect, maximize the potential of students, inspect disadvantages, compensate for shortcomings, and

* ***Corresponding author's*** e-mail: taiyuanyuan@yeah.net

obtain the best effect.

2 Establishment of an output-based C^2GS^2 model

2.1 DEA (C^2GS^2) EVALUATION MODEL

Based on the basic principle of DEA, an evaluation model of the English writing teaching effect is established as follows.

Assuming that *n* English writing teachers are to be evaluated (i.e., *n* decision-making units, expressed as DMU), each teacher has *m* input variables and *s* output variables. X_j and Y_j are the input and output vectors of the j^{th} fund. Then,

$$Xj = \left(x_{1j}, x_{2j}, \cdots, x_{mj}\right)^T, Yj = \left(y_{1j}, y_{2j}, \cdots, y_{mj}\right)^T,$$

where x_{ij} is the input quantity corresponding to the i^{th} input variable of the j^{th} English writing teacher and yrj is output quantity corresponding to the r^{th} input variable of the j^{th} English writing teacher (j=1,2,⋯,n; i=1,2,⋯,m;r=1,2,⋯,s). $v = \left(v_1, v_2, \cdots, v_m\right)^T$ and $u = \left(u_1, u_2, \cdots, u_m\right)^T$ are the weight vectors of the input and output variables. The DEA (C^2GS^2) model utilized to evaluate the English writing teaching effect of the j^{th} English writing teacher can be classified as an evaluation model based on input variables and an evaluation model based on output variables. Generally, the weak traditional model is as follows.

(1) The evaluation model based on the input variable is expressed as

$$(\mathrm{F})\begin{cases} \min\theta = \theta^* \\ st - \sum_{j=1}^{n} \lambda_j X_j + \theta X_o \geq 0 \\ \sum_{j=1}^{n} \lambda_j Y_j \geq Y_o \\ -\sum_{j=1}^{n} \lambda_j = 0 \\ \lambda_j \geq 0,\ j = 1,2,\cdots,n \end{cases} \tag{1}$$

After slack variable treatment, the final mode is obtained as follows:

$$(\mathrm{F}_1)\begin{cases} \min\theta = \theta^* \\ st\sum_{j=1}^{n} \lambda_j X_j + \theta X_o - S^- = 0 \\ \sum_{j=1}^{n} \lambda_j Y_j - S^* = Y_o \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0,\ j = 1,2,\cdots,n \end{cases} \tag{2}$$

(2) The evaluation model based on the output variable is expressed as

$$(\mathrm{Q})\begin{cases} \max\alpha = \alpha^* \\ st\sum_{j=1}^{n} \lambda_j X_j \leq X_o \\ -\sum_{j=1}^{n} \lambda_j Y_j + \alpha Y_o \leq 0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0,\ j = 1,2,\cdots,n \end{cases} \tag{3}$$

After slack variable treatment, the final mode is obtained as follows:

$$(\mathrm{Q}_1)\begin{cases} \max\alpha = \alpha^* \\ st\sum_{j=1}^{n} \lambda_j X_j + S^* = X_o \\ -\sum_{j=1}^{n} \lambda_j Y_j + \alpha Y_o + S^* = 0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0,\ j = 1,2,\cdots,n \end{cases} \tag{4}$$

The optimal solutions of the above linear programming are λ^*, α*, S^{*+}, and S^{*-}. The effects of DMU on English writing teaching include the following.

If a zero value exists for components of α*=1, S^{*+}, and S^{*-}, DMU is effective for weak DEA (C^2GS^2). Assuming that the component of any S^{*-} is greater than 0, the input index data are ineffective. In other words, the expected teaching is not reached. If the component of any S^{*+} is greater than 0, the output index data fail to reach the expectation, and an increase in potential exists.

If the components of α*=1, S^{*+}, and S^{*-} are 0, then DMU is effective for weak DEA (C^2GS^2). The teaching level of English writing gains the largest benefit and reaches the expected value. In teaching, the students' potential is fully maximized, and various resources are effectively utilized. The largest output effect is gained.

If α*<1, then DMU is ineffective for weak DEA (C^2GS^2). In the teaching process, teachers fail to maximize the teaching resources. The output scale is too large, and the teaching effect does not reach the best level.

In the DEA principle, the necessary and sufficient condition of DMU0 as a traditional DEA teaching effect

(C^2GS^2) is that the optimal value of Model F1 or Q1 is 1. Moreover, point (X0, Y0) corresponding to DMU0 of the traditional weak DEA teaching effect is located at the leading surface of the teaching effect (or relative effective surface of DEA).

2.2 OUTPUT-BASED C^2GS^2 EVALUATION MODEL

The DMU0 of the traditional weak DEA teaching effect (C^2GS^2) can be adjusted from four aspects to make the effect strong. The DMU of non-DEA effectiveness based on the output variable evaluation model has two adjustment methods. First, when the optima solutions are $\lambda*$ and α* and the input remains unchanged, the output variable is adjusted to α* Y, and DMU corresponding to (X_0,α* Y_0) is the DEA effectiveness (C^2GS^2). Second, when the optima solutions are $\lambda*$, α* , S^{*+}, and S^{*-}, the input and output variables are simultaneously adjusted as follows:

$$\begin{cases} \hat{X}_0 = X_0 - S^{*-} \\ \hat{Y}_0 = Y_0 - S^{*+} \end{cases} \tag{5}$$

According to linear programming duality theory and linear programming slack theorem, the following can be gained for DMU: if any optimal solution of DMU is $\lambda*$, α* , S^{*+}, and S^* and X_0-α*=1 is met, DMU is effective for traditional weak DEA; if any optimal solution of DMU not just meets X_0-α*=1 but also meets S^{*+} =S^{*-}=0, DMU is effective for improved output-based DEA. In addition, DMU is adjusted to $(\hat{X}_0, \hat{Y}_0)$ on the basis that the input and output quantities are (X_0, Y_0). In other words, the DMU can become one with a strong DEA teaching effect (C^2GS^2).

The projection of the non-effective or inefficient teaching factor on the DEA relative effective surface actually provides a feasible scheme to improve non-effective English writing teaching and indicates the influence causes and degree of each factor on the DEA teaching effect. It also offers an improvement objective and gap in the aspect of teaching methods and learning effects for English writing teachers. This condition is based on the fact that improved output DEA method is superior to traditional English writing teaching effect evaluation method.

3 Empirical analysis of English writing teaching effect with output-based C^2GS^2 model

3.1 EVALUATION INDEX SYSTEM

In the evaluation of the English writing teaching effect, the input indexes mainly involve teachers and students. In this study, 10 English writing teachers were selected from a college as research samples. The teaching effects of the 10 teachers in 2013 was studied. Each English writing teacher serves as an evaluation unit DMU. Three input evaluation indexes and three output evaluation indexes were set. Table 1 provides detailed definitions of each index.

TABLE 1 Evaluation index system for English writing teaching effect

	Definition of index	Description of index
Input index	X_1: students' mean total English score before the semester begins	Top hundred-mark system for calculation
	X_2: students' mean English writing score before the semester begins	Top hundred-mark system for calculation
	X_3: students' mean English grammar score before the semester begins	Top hundred-mark system for calculation
Output index	Y_1: students' mean total English score after the semester ends	Quantify to a hundred-mark system
	Y_2: students' mean richness degree of English writing contents after the semester ends	Quantify to a hundred-mark system
	Y_3: students' mean English writing grammar and skills after the semester ends	Quantify to a hundred-mark system

3.2 DATA VARIATION AND EMPIRICAL ANALYSIS

The input and output index data of the 10 English writing teachers according to the DEA evaluation index system are shown in Table 2.

TABLE 2 Input and output index data of the DEA evaluation model

DMU	Input index			Output index		
	X_1	X_2	X_3	Y_1	Y_2	Y_3
DMU_1	80	70	87	89	85	91
DMU_2	85	87	88	85	83	90
DMU_3	78	89	78	88	86	89
DMU_4	89	76	91	80	83	84
DMU_5	84	80	79	78	83	73
DMU_6	72	85	70	80	87	75
DMU_7	70	87	67	87	90	84
DMU_8	86	78	90	84	85	86
DMU_9	81	70	87	80	82	81
DMU_{10}	74	65	79	79	85	75

During DEA analysis, the output data should be greater than 0; otherwise, data conversion is required. Given that the data in this study are above 0, data conversion was not necessary. In accordance with the previous output model formula, the linear programming model of DMU_1 is

$$\min\left[\theta - 10^{-s}\left(s_1^- + s_2^- + \cdots + s_{10}^-\right)\right]$$

$$\begin{aligned} st \quad & 80\lambda_1 + 85\lambda_2 + 78\lambda_3 + \cdots + 74\lambda_{10} + s_1^- = 80\theta \\ & 70\lambda_1 + 87\,\lambda_2 + 89\lambda_3 + \cdots + 65\lambda_{10} + s_2^- = 70\theta \\ & 87\lambda_1 + 88\lambda_2 + 78\lambda_3 + \cdots + 79\lambda_{10} + s_3^- = 87\theta \\ & \cdots \\ & 91\lambda_1 + 90\lambda_2 + 89\lambda_3 + \cdots + 75\lambda_{10} + s_{10}^- = 91\theta \end{aligned}$$

where $\lambda_i \geq 0 (i = 1,2,\cdots,7)$.

Similarly, the linear programming models of the other nine English teachers were obtained via simplex method. The linear programming tool LP in the MATLAB software was applied for calculation. Table 3 shows the values calculated with the traditional C^2GS^2 model for the 10 teachers.

TABLE 3 Calculation results of the traditional C^2GS^2 model

DMU	λ^T	$(s^-)^T$	$(s^+)^T$	θ
DMU_1	(1.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_2	(0.3420,0.0000,0.2350,0.0000,0.4320,0.0000,0.0000,0.0000,0.0000)	(30.908, 0.0000, 29.120)	(5.0690,0.0000,9.0034)	0.8054
DMU_3	(0.0000,0.0000,1.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_4	(0.0000,0.0000,0.0000,1.0000,0.0000,0.0000,0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_5	(0.0000,0.0000,0.9080,0.0000,0.0000,0.6430,0.0000,0.7890,0.0000,0.0000)	(0.0000, 0.0000, 109.10)	(0.0000,0.0000,8.0076)	0.9087
DMU_6	(0.0000,0.0000,0.0540,0.0000,0.0000,0.0000,0.0345 0,0.0000,0.8970,0.0000)	(45.706, 0.0000, 0.0000)	(9.3498,0.0000,11.007)	0.7838
DMU_7	(0.0000,0.23400,0.0000,0.9010,0.0000,0.0000,0.0000, 0.0000,0.0000,0.0000)	(0.0000, 7.8970, 10.108)	(0.0000,0.0000,18.005)	0.9234
DMU_8	(0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,1.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_9	(0.0000,0.0000,0.6500,0.0000,0.7970,0.0000,0.0000,0.0000,0.0000,0.9178)	(33.651, 0.0000, 0.0000)	(0.0000,11.004,0.0000)	0.7886
DMU_{10}	(1.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,1.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000

Table 3 shows that the English writing teaching effects of DMU_1, DMU_3, DMU_4, DMU_8, and DMU_{10} are effective. The teaching efficiency of these five teachers reached the expected degree. Teaching resources are effectively utilized, and students are able to maximize their potential under the guidance of teachers in the English learning process. However, the other English writing teachers are ineffective. Their teaching effects failed to reach the expectation and still have a certain gap; the richness of the writing contents is low, or writing grammar or skills are not mature and perfect enough and thus require further improvement. The research results also indicate the direction for students with ineffective learning effect, the relative effectiveness of the output (C^2GS^2) model, and its remaining ineffectiveness. Further research and discussions can be conducted for the surplus value (s+) and deficit value (s^-) to obtain a side conclusion. Given that this does not involve the contents of this paper, no detailed analysis was made.

On this basis, the C^2GS^2 model was used to calculate and analyze the result, as shown in Table 4.

TABLE 4 Calculation results of the traditional C^2GS^2 model

DMU	λ^T	$(s^-)^T$	$(s^+)^T$	θ
DMU_1	(1.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_2	(0.0000,0.8970,0.0000,0.0000,0.0000,0.0000,0.0000, 0.9807,0.0000,0.0000)	(0.0000, 0.0000, 43.800)	(0.0000,0.0000,15.708)	0.8098
DMU_3	(0.0000,0.0000,1.0000,0.0000,0.0000,0.0000,0.0000, 0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_4	(0.0000,0.0000,0.0000,1.0000,0.0000,0.0000,0.0000, 0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_5	(0.0000,0.0000,0.0000,0.0000,1.0000,0.0000,0.0000, 0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_6	(0.0000,0.0000,0.0540,0.0000,0.0000,0.0000,0.0345 0,0.0000,0.8970,0.0000)	(33.708, 0.0000, 10.219)	(0.0000,0.0000,11.007)	0.9039
DMU_7	(0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,1.0000, 0.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_8	(0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000, 1.0000,0.0000,0.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000
DMU_9	(0.3432,0.0000,0.0000,0.0000,0.9978,0.0000,0.0670, 0.0000,0.0000,0.9178)	(33.651, 45.040, 0.0000)	(0.0000,10.034,20.000)	0.8790
DMU_{10}	(1.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000, 0.0000,0.0000,1.0000)	(0.0000, 0.0000, 0.0000)	(0.0000,0.0000,0.0000)	1.0000

Table 4 shows that the traditional DEA analysis model is ineffective for DMU_5 and DMU_7. However, the improved output-based C^2GS^2 model is ineffective for DMU_5 and DMU_7 as well as DMU_1, DMU_3, DMU_4, DMU_8, and DMU_{10}. The final ranking is as follows: DMU_1 (DMU_3, DMU_4, DMU_8, and DMU_{10}) > DMU_6 > DMU_9 > DMU_2. This ranking differs slightly with the ranking according to teaching performance because under the output-based C^2GS^2 model, the comprehensive factors of teaching objects, such as different learning foundations and different improvement abilities, are considered during the evaluation of the English teaching effect. The model evaluates different learning foundations and writing progress more objectively. In the English writing teaching process, teachers should clearly cognize English grammar, writing skills, and content richness to further adopt effective measures and promote the optimal progress of students.

4 Conclusions

With the globalization trend, English study has become a skill necessary to adapt to current social development. English writing teaching has elicited much attention. In writing teaching, teachers should pay attention to formative evaluation, focus on students' writing process, and carry out student-centered teaching evaluation to reach the effect of "promoting writing progress through evaluation." To apply formative evaluation, an in-depth understanding of its concept and features is first required. Relevant theories of the output-based C^2GS^2 model are applied to evaluate the English writing teaching effect, which can effectively overcome the oneness and scientificity of traditional teaching effect evaluation, evaluate students' mastery of writing knowledge and resource utilization, and reveal the direction for further improvement of the teaching effect. Furthermore, with the development of computer technology, programming software can be applied to rapidly and efficiently process input and output data. Thus, the complexity of mathematical calculation is simplified. This study provides new thoughts for other analysis methods to some extent and contributes to the improvement of teaching quality. However, many problems remain from theory to practice. The teaching reform system is still not perfect and poses a great challenge to both teachers and students who

are used to traditional teaching effect evaluation.

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Author

Tai Yuanyuan, 1977.01, Heze City, Shandong Province, PR China

Current position, grades: lecturer of Department of Foreign Languages, Heze University, PR China.
University studies: She received her mast degree from QuFu Normal University in PR China.
Scientific interest: Her research interest fields include English Linguistics.
Publications: more than 12 papers published in various journals.
Experience: She has teaching experience of 11 years, has completed 3 scientific research projects.