Pertanika J. Soc. Sci. & Hum. 21 (2): 757 - 772 (2013)

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Assessing the Teaching and Learning Performance of English Freshmen Courses by Applying Data Envelopment Analysis and Management Matrix

Bernard Montoneri[1]*, Chia-Chi Lee[2], Tyrone T. Lin[3] and Shio-Ling Huang[2]

[1]*Department of English Language, Literature and Linguistics, Providence University, Taichung, Republic of China (Taiwan)*
[2]*Department of Accounting Information, National Taipei College of Business, Taipei, Republic of China (Taiwan)*
[3]*Department of International Business, National Dong Hwa University, Hualien, Republic of China (Taiwan)*

ABSTRACT

In a country like Taiwan, where Chinese is the official language, many students struggle to improve their English writing skills. The system of students' ratings of teachers at the end of each semester can provide valuable information concerning students' opinions. This paper selects 50 classes of freshmen following writing courses in a university of Taiwan from 2004 to 2006. We adopted the data envelopment analysis to identify the relative performance efficiencies of each class. This research proposed a management matrix of the selected classes' performance with 4 quadrants which could help them to know in what quadrant they are located. The results of this paper, which were expected to reveal that only a few classes are efficient, could help to provide some concrete and practical learning and teaching strategies for the classes with lower average scores.

Keywords: Data envelopment analysis (DEA), English writing, teaching and learning performance, proposed management matrix

ARTICLE INFO

Article history:
Received: 21 October 2011
Accepted: 28 August 2012

E-mail addresses:
bmon@pu.edu.tw (Bernard Montoneri),
cclee.vera@msa.hinet.net (Chia-Chi Lee),
tjlin@mail.ndhu.edu.tw (Tyrone T. Lin),
slhuangmon@gmail.com (Shio-Ling Huang)
* Corresponding author

INTRODUCTION

Taiwan has a service-oriented and export-driven economy. Even though China has recently become Taiwan's largest import and export partner, the U.S. remains the second export partner (Ministry of Economic Affairs, 2010). Many Taiwanese continue to go to America for higher education

ISSN: 0128-7702

and develop relationships with American businesses. English remains an indispensable communication tool and a valuable skill for the students who expect to enter the job market.

In a country like Taiwan, where Chinese is the native language, students have difficulty in expressing themselves in English. Therefore, it is essential for students to improve their writing skill. The system of students' rating of teachers at the end of each semester can provide valuable information concerning students' opinions. Adequate indicators of mutual evaluation between teachers and students can help to enhance teaching efficiency and learning performance.

The paper applies the data envelopment analysis (DEA) to explore key indicators contributing to students' learning performances for English freshmen writing courses in a university of Taiwan. The results of the paper may allow teachers to know how much improvement they need to make in which performance indicator? A management matrix with 4 quadrants may help the educational policy-makers to design management measures and to encourage the evaluated units with lower efficiency to make progress little by little.

The remainder of the paper is organized as follows: the literature review presents some academic studies related to the current work. The "materials and methods" section introduces the DEA method and the selected input and output indicators. The penultimate section entitled "results and discussion" analyzes and comments on the obtained numerical results from the empirical data. The final section draws the conclusions and suggestions.

LITERATURE REVIEW

DEA is a reliable and robust quantitative evaluation method which has notably been used to assess the efficiency of higher education institutions (Ahn *et al.*, 1989; Glass *et al.*, 1998; Abbott & Doucouliagos, 2003; Johnes, 2005; Madden *et al.*, 1997; Colbert *et al.*, 2000) and the teaching performance of various courses (McGowan & Graham, 2009; Ismail, 2009). Lin (2009) developed an evaluation approach for measuring and ranking the efficiency of tutors in some higher education institutions (HEIs) in Taiwan. He proposed to use an IDEA (imprecise data envelopment analysis) model based on the BCC (Banker-Charnes-Cooper) model in order to determine the final ranking of the evaluated tutors.

Author *et al.* (2011) applied DEA to assess the performance of English courses in a university of Taiwan. They proposed an output oriented model and showed that some evaluated classes with higher actual values of inputs and outputs have lower efficiency because the relative efficiency of each evaluated class is measured by their distance from the efficiency frontier. This paper also demonstrates that the benchmarking characteristics of the DEA model can automatically segment all the evaluated classes into different levels based on the indicators fed into the performance evaluation mechanism.

Management matrix was first implemented in the aerospace industry during the late 1950s. Pred (1967) introduced the concept of the behavioural matrix in connection with a theory of behavior and location. According to Davis and Lawrence (1977), a matrix organization could include various organizing principles such as function, product, and area. They stated that a successful matrix must develop through successive phases. Selby (1987) proposed to use Pred's behavioural matrix as a tool for the analysis of enterprises in rural areas.

Taylor *et al.* (2004) applied a matrix model to the field of education. They analyzed why there were very few non-credentialed teachers remained in teaching in the Los Angeles Unified School District (half of the new teachers left after their first year). They devised a four-cell matrix of teaching practice classification based on various works (Edwards, 2000; Canter & Canter, 1976; Coloroso, 1994). Jung (2005) analyzed and organized a variety of approaches found in use in teacher training into a four-cell matrix. Teachers can be trained to learn how to use information and communication technology (ICT) or teachers can be trained via ICT. The matrix is divided into four quadrants: ICT as a main content focus, ICT as a core delivery technology, ICT as a part of content or methods, ICT as a facilitating or networking technology.

MATERIALS AND METHODS

According to Samoilenko and Osei-Bryson (2008), DEA is an attractive tool, which can measure the relative efficiency of evaluated classes called decision making units (DMUs). The paper aims at knowing how much improvement teachers need to make in what indicator by applying DEA model and a concept of management matrix. The analysis of the main performance indicators can indicate the evaluated classes' relative efficiencies. The proposed matrix is expected to help teachers to know in what quadrant they are located and to encourage the evaluated classes with lower efficiency to make progress little by little.

DEA Model and Charnes-Cooper-Rhodes (CCR) Model

DEA is a quantitative method which can receive multiple inputs and produce multiple outputs (Lee, 2009). Charnes *et al.* (1978) estimated efficiency frontier by the ratio of two linear combinations and measured the relative efficiency of the evaluated units called decision-making units (DMUs). This method is known as the "Charnes-Cooper-Rhodes (CCR) model" or "CCR model". The efficiency value of the CCR model corresponds to the overall technical efficiency of an evaluated unit. If the efficiency value equals 1, the evaluated unit is efficient; if the efficiency value is less than 1, the evaluated unit needs some improvement.

Choice of Evaluated Units

The study selected some freshmen who were following writing courses in the Department of English Language at the University of Taiwan from 2004 to 2006. A total of 50 classes were selected as the DMUs, which were labelled as D1 to D50.

Selection of Input and Output Indicators

The performance of the DMUs was interpreted by analyzing the input and the output indicators. The data were based on the average score of the student survey of teachers at the end of each semester for each class. Two inputs and two outputs were chosen for the evaluation model, and the variation of inputs had a significant influence on the outputs. The meaning of the 4 indicators, rated from 1 (very unsatisfied) to 5 (very satisfied) by students, is explained as follows:

Input 1:	Preparation of teaching contents: reflecting students' opinions concerning the preparation of teaching materials.
Input 2:	Teaching skills: indicating whether students think teachers' teaching methods and tools are suitable for them and whether they can assimilate the course.
Output 1:	Fair grading: showing whether students believe teachers are grading them fairly.
Output 2:	Students' learning performance: students give their impressions about the knowledge they have acquired after a semester of English writing training.

Correlation Analysis of Input and Output Indicators

The Pearson correlation coefficient test was used to analyze whether the principle of isotonicity of two inputs and two outputs was satisfied. The calculus result indicated that the correlation coefficients (O1, I1), (O1, I2), (O2, I1), and (O2, I2) were 0.961, 0.939, 0.936, and 0.908 respectively. They are all above 0.9 with a statistical significant level of 1%. In general, there are three statistical significant levels, 1%, 5% and 10%. DEA method requests that the correlations between the inputs and the outputs should be positive. A Pearson correlation coefficient superior to 0.7 means the correlations between the inputs and outputs are highly correlated.

TABLE 1
Correlation coefficients between input and output items

Inputs / Outputs	I1 Preparation of teaching contents	I2 Teaching skill
O1 (Fair grading)	0.961***	0.939***
O2 (Learning performance)	0.936***	0.908***

Note: *** denotes the statistical significant level at 1%.

RESULT AND DISCUSSION

Frontier Analyst 4.0 was used to calculate the evaluation data in this study. The results of numerical analysis are expected to show whether the existing teaching scale is efficient. An application of management matrix based on the DMUs' efficiencies obtained by DEA model can give indications about the teaching effectiveness of English writing courses in order to formulate some useful language teaching improvement suggestions.

Analysis of the Overall Teaching Efficiency and Performance Indicators

The relative overall teaching efficiency and other performance indicators of all the 50 DMUs are calculated under the output oriented CCR model of DEA. The empirical results are listed in Table 2, which is ranked by CCR score, that is, the relative overall teaching efficiency. According to the ranking of the CCR score, 50 DMUs were divided into two groups; the first 50% (the 25 DMUs with a better performance) are arranged on the left side of Table 2 and the others are on the right side. The DMUs which have the overall teaching efficiency equaling 1 are considered efficient and segmented into different groups according to their inputs or outputs values in order to build up efficient frontier curves. The efficient frontier curve analyzes how much effort and room for improvement is necessary for the inefficient DMUs' output performances to come close to the efficient frontier and to reduce the gap between the actual output performance and the target output performance.

The average overall teaching efficiency of all the 50 DMUs is 0.962. D6, D22, D37, D41 and D49 have the best performance with a value of 1 and form the efficient frontier curves. It was observed that on the left side of Table 2, the average of the 25 better DMUs is 0.982; on the right side, the average is 0.941.

In Table 2, the column "Room for improvement" indicates how much improvement is needed for the inefficient DMUs and for what indicators under the current inputs according to the output oriented CCR model of DEA. Therefore, the values of inputs' room for improvement are always 0 (without additional inputs needed) or negative (need to reduce the inputs). For example, D1 (ranked 25) has the lowest overall teaching efficiency among the first half of all the DMUs, 0.965. There is still a little effort to make in fair grading and in students' self-recognition of learning performance. Teachers should clarify the grading criteria at the beginning of the semester; If students know what to prepare for the exams, their motivation will probably increase. Teachers should tell their students the type of questions they will ask for the coming exam. For example, in a course of English composition, teachers can tell their students that they have to know: (1) Figures of speech studied during the class, their definition and an example (20 points; 5 points per figure); (2) How to write a summary (20 points); (3) A list of irregular verbs studied during the class (10 points; 1 point per verb); (4) How to write a detailed outline (30 points); and (5) Vocabulary studied during the class (20 points; 2 points per word). Moreover, teachers should guide their students and offer help before the exams such as during the office hours. If students know the exact percentage of each exam and assignment, they will probably feel less stressed and confused (for example, 25% for the mid-term exam, 25% for the final, 25% for their assignments at home, and 25% for their attendance and attitude during the class). Finally, students also need to feel that their teachers are grading them fairly and that they deserve their grades, even when they are lower . As a result, students will acquire sufficient knowledge to cover the course's important topics; thus, the value of O2 (students' self-recognition of learning performance) can be increased and students' learning motivation and performance can be enhanced at the same time.

Concerning the column I1 (room for improvement in the preparation of teaching contents), only D25 (ranked 6) and D3 (ranked 20) have the values of -6.3% and -3.9%, respectively. It indicates that the preparation of teaching materials and the course contents are too much and too complicated for students to assimilate. Hence, teachers should moderate the quantity of course contents in order to improve students' learning performances. Based on our personal teaching experiences, it seems that if teachers who usually teach senior students or graduate students are assigned to teach to freshmen, they tend to have difficulty to adapt to their level. That is, they will probably teach freshmen the way they teach more advanced students. As a result, freshmen can feel lost; some of them will even give up if they believe the course is too difficult.

As for the column I2 (room for improvement in the teaching skills), the classes D16, D2, D11, D21, D17, and D30, have the improvement values of -1.2%, -3.1%, -7.3%, -2.4%, -0.5%, and -0.9%, respectively. It means that the teachers of these DMUs should adjust their teaching skills in order to increase their relative overall teaching efficiency. For example, sometimes, teachers' over-explanation does not help students better understand the course. Instead, it will probably make students feel bored and become less attentive.

"Refs" in Table 2 denotes the number of times the efficient DMUs are referred to by the inefficient DMUs. 5 DMUs have Refs values because they are efficient. For example, D37 is the DMU the most referred to; there are 42 inefficient DMUs referring to it. "Peers" denotes the number of efficient DMUs in the inefficient DMUs' reference set, that is, the number of times the inefficient DMUs are referring to other efficient DMUs. For example, the class D1 (ranked 25) refers 2 times to other DMUs, that is, there are two efficient DMUs in its reference set. In other words, D1's relative overall teaching efficiency and performance indicators are obtained based on these two efficient DMUs in its reference set. All the teachers of writing courses have more or less the same level of knowledge. The major difference in the learning performance probably comes from the atmosphere in the class and the relationship between teachers and students: they are fundamental and perhaps more crucial than the preparation of the course contents. If a student does not feel comfortable during the class, he/she will probably give a bad rating to his/her teacher, whether the teacher prepares his/her course seriously or is punctual (for example, some students in the class may say that a teacher is never on time, even if he/she is). Writing courses are very demanding for both teachers and students. If the atmosphere

TABLE 2
Overall teaching efficiency and room for improvement of DMUs under CCR model

DMU name	CCR score	Rank	Refs	Peers	Room for improvement (%)				DMU name	CCR score	Rank	Refs	Peers	Room for improvement (%)			
					O1	O2	I1	I2						O1	O2	I1	I2
D6	1.000	1	14	0	0	0	0	0	D17	0.963	26	0	1	3.8	6.4	0	-0.5
D22	1.000	1	30	0	0	0	0	0	D30	0.963	26	0	1	3.8	4.1	0	-0.9
D37	1.000	1	42	0	0	0	0	0	D15	0.961	28	0	3	4	4	0	0
D41	1.000	1	30	0	0	0	0	0	D44	0.953	29	0	3	4.9	4.9	0	0
D49	1.000	1	3	0	0	0	0	0	D47	0.953	29	0	3	5	5	0	0
D25	0.999	6	0	2	0.1	0.1	-6.3	0	D28	0.951	31	0	2	5.1	6.2	0	0
D29	0.997	7	0	3	0.4	0.4	0	0	D48	0.951	31	0	2	5.1	11.2	0	0
D45	0.995	8	0	3	0.5	0.5	0	0	D9	0.949	33	0	3	5.4	5.4	0	0
D38	0.987	9	0	3	1.3	1.3	0	0	D19	0.948	34	0	2	5.5	5.8	0	0
D16	0.985	10	0	2	1.5	1.5	0	-1.2	D50	0.948	34	0	3	5.5	5.5	0	0
D12	0.984	11	0	2	1.6	4	0	0	D7	0.947	36	0	3	5.7	5.7	0	0
D24	0.983	12	0	3	1.7	1.7	0	0	D18	0.943	37	0	3	6.1	6.1	0	0
D5	0.980	13	0	3	2	2	0	0	D34	0.942	38	0	3	6.1	6.1	0	0
D31	0.978	14	0	3	2.2	2.2	0	0	D27	0.942	38	0	2	6.1	6.8	0	0
D10	0.978	14	0	3	2.2	2.2	0	0	D32	0.941	40	0	3	6.3	6.3	0	0
D2	0.973	16	0	2	2.8	2.8	0	-3.1	D35	0.941	40	0	2	6.3	9.4	0	0
D20	0.971	17	0	3	3	3	0	0	D43	0.940	42	0	3	6.4	6.4	0	0
D42	0.971	17	0	2	4.9	3	0	0	D39	0.938	43	0	3	6.6	6.6	0	0
D11	0.969	19	0	2	3.2	3.2	0	-7.3	D36	0.938	43	0	2	6.6	8.1	0	0
D46	0.968	20	0	3	3.3	3.3	0	0	D26	0.934	45	0	3	7.1	7.1	0	0
D3	0.968	20	0	2	3.3	3.3	-3.9	0	D33	0.932	46	0	3	7.3	7.3	0	0
D21	0.967	22	0	2	3.4	3.4	0	-2.4	D8	0.926	47	0	3	8	8	0	0
D4	0.967	22	0	2	3.4	9.3	0	0	D13	0.913	48	0	2	9.5	11.8	0	0
D40	0.966	24	0	3	3.5	3.5	0	0	D14	0.912	49	0	3	9.6	9.6	0	0
D1	0.965	25	0	2	3.6	5.6	0	0	D23	0.906	50	0	3	10.3	10.3	0	0
Average	0.982				1.92	2.25			**Average**	0.941				6.24	6.96		

Note: CCR score refers to the DMUS' relative overall teaching efficiency. "Refs" denotes the number of times the efficient DMUs are referred to by the inefficient DMUs. "Peers" denotes the number of efficient DMUs in the inefficient DMUs' reference set. I1 is the preparation of teaching contents; I2 is the teaching skills; O1 is the fair grading; O2 is the students' self-recognition of their learning performance.

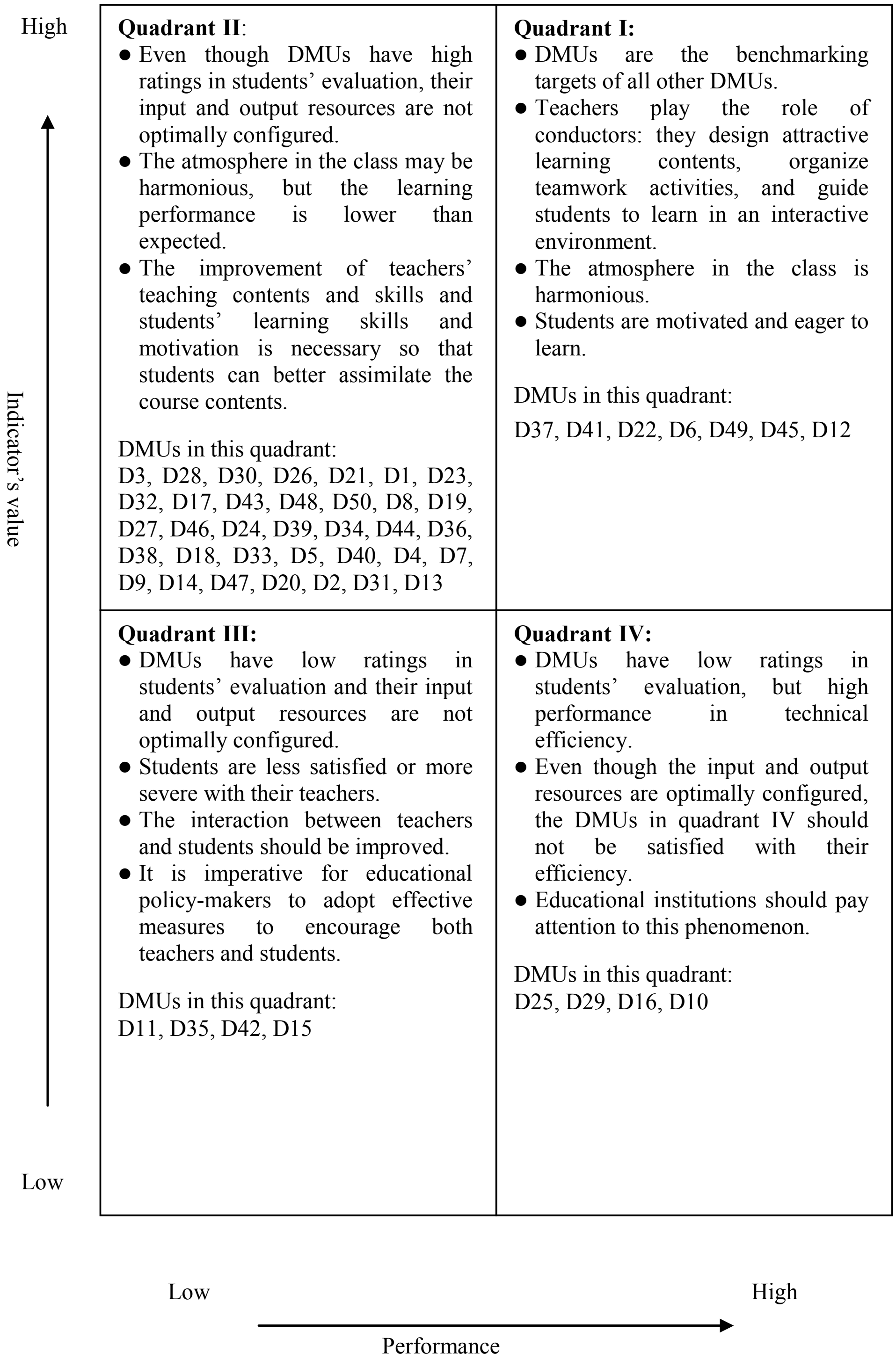
in the class is good, students will try their best and work more seriously. However, if the teaching contents are too difficult for students to assimilate, they will probably loose their motivation to learn and give up.

Classification of DMUs

The relative overall teaching efficiency presented in the previous section is calculated under the CCR model, which is a scale invariant model. Scale invariant means the variance of one unit in inputs will result in the variance of one unit in outputs. However, Banker *et al.* (1984) expanded the concept of CCR model and changed DMUs to be variable returns to scale (VRS). That is, the variance of one unit in inputs will result in the variance of more or less than one unit in outputs. Therefore, they assumed that the overall technical efficiency (that is, the overall teaching efficiency in our study) could be divided into pure technical efficiency and scale efficiency, named "BCC score" and "Scale score" in Table 3. This particular method is called the "Banker-Charnes-Cooper model" or "BCC model". As for the teaching performance issue in the current paper, the pure technical efficiency means whether teachers are using outdated or updated teaching methods and materials. Thus, teachers may have to reassess their methods. For example, they can enforce their computer skill, create a personal teaching website, and use multimedia during the class. When the DMUs' scale efficiency is inferior to 1, it could probably be due to students having difficulty in assimilating or appreciating the teaching contents if the method is considered to be too difficult.

In order to detail the origins of DMUs' inefficiency, a calculation of the output oriented BCC model was calculated for all the 50 evaluated classes. According to their BCC and scale scores, these DMUs are firstly classified into efficient DMUs (BCC score= 1) and inefficient DMUs (BCC score <1). Then, they were segmented again by each DMU's scale score. At the university studied in this paper, teachers obtaining students' rating lower than 3.5 points are considered as not qualified to teach the course and this must be changed in the following semesters. Moreover, teachers obtaining students' rating higher than 4.0 points are generally considered as those with good teaching performances. Therefore, the 50 DMUs were divided into three groups according to their average values of evaluated indicators: high (average value>4.0), medium (3.5<=average value<4.0), and low (average value<3.5), as shown in Table 3.

In order to clarify the average characteristics of each grid, the average value of each indicator in the grid was calculated and the two indicators with lowest and highest average value wer also determined; these were labelled as "min" and "max", as displayed in Table 3. For example, "min: I2" means the average value of indicator I2 is the lowest; "max: O1" means the average value of indicator O1 is the highest. In addition, each grid was assigned a quadrant, as explained in Section 4.3 (Application of Management matrix on teaching performance improvement) and in Fig.1. The classification of DMUs under BCC model is shown in Table 3.



Quadrant II: ● Even though DMUs have high ratings in students' evaluation, their input and output resources are not optimally configured. ● The atmosphere in the class may be harmonious, but the learning performance is lower than expected. ● The improvement of teachers' teaching contents and skills and students' learning skills and motivation is necessary so that students can better assimilate the course contents. DMUs in this quadrant: D3, D28, D30, D26, D21, D1, D23, D32, D17, D43, D48, D50, D8, D19, D27, D46, D24, D39, D34, D44, D36, D38, D18, D33, D5, D40, D4, D7, D9, D14, D47, D20, D2, D31, D13	**Quadrant I:** ● DMUs are the benchmarking targets of all other DMUs. ● Teachers play the role of conductors: they design attractive learning contents, organize teamwork activities, and guide students to learn in an interactive environment. ● The atmosphere in the class is harmonious. ● Students are motivated and eager to learn. DMUs in this quadrant: D37, D41, D22, D6, D49, D45, D12
Quadrant III: ● DMUs have low ratings in students' evaluation and their input and output resources are not optimally configured. ● Students are less satisfied or more severe with their teachers. ● The interaction between teachers and students should be improved. ● It is imperative for educational policy-makers to adopt effective measures to encourage both teachers and students. DMUs in this quadrant: D11, D35, D42, D15	**Quadrant IV:** ● DMUs have low ratings in students' evaluation, but high performance in technical efficiency. ● Even though the input and output resources are optimally configured, the DMUs in quadrant IV should not be satisfied with their efficiency. ● Educational institutions should pay attention to this phenomenon. DMUs in this quadrant: D25, D29, D16, D10

Fig.1: Management matrix of DMUs' performance

It was observed that D37 and D41 are located in the grid with the BCC score =1 and scale score = 1 and they belonged to the high group. Their lowest indicator is I2 (the teaching skills), while their highest indicator is O2 (the students' self-recognition of learning performance). In particular, D37 and D41 are located in quadrant I. From the viewpoint of efficiency, BCC score =1 means D37 and D41's ratio of linear combination of outputs divided by the linear combination of inputs equals 1. In other words, the ratio of teacher's fair grading and students' self-recognition of learning performance to teacher's preparation of teaching contents and teaching skills are efficient. However, from the perception of students' satisfaction about the course, D37 and D41 belonged to the high group according to the classification of four indicators' average value; they obtained an average of 4.15 in O2 (the students' self-recognition of learning performance), but only of 3.85 in I2 (the teaching skills). This also means that D37 and D41 are efficient, and even though students think that the teaching skills can be improved, they are quite satisfied with the acquired knowledge.

Among all the grids, only the grid (BCC score=1, Scale score=1, High) has "max: O2". It also means that only the students in classes D37 and D41 felt more satisfied

TABLE 3
Classification of DMUs under BCC model

Category Group	Efficient DMUs (BCC score=1)		Inefficient DMUs (BCC score <1, Scale score <1)	
	Scale score =1	Scale score <1	BCC score >Scale score	BCC score <Scale score
High	D37, D41 min: I2 max: O2 Quadrant: I	D45, D12 min: I2 max: O1 Quadrant: I	D3, D28, D30, D26 min: I2 max: I1 Quadrant: II	D1, D23, D32, D17, D43, D48, D50, D8, D19, D27, D46, D24, D39, D34, D44, D36, D38 min: O2 max: I1 Quadrant: II
Medium	D22, D6, D49 min: I2 max: O1 Quadrant: I	D25 min: I2 max: I1 Quadrant: IV	D21 min: O2 max: O1 Quadrant: II	D18, D33, D5, D40, D4, D7, D9, D14, D47, D20, D2, D31, D13 min: I2, O2 max: I1 Quadrant: II
Low	- Quadrant: IV	D29, D16, D10 min: I2, O2 max: O1 Quadrant: IV	D11 min: O2 max: O1 Quadrant: III	D35, D42, D15 min: I2 max: O1 Quadrant: III

Note: "min" or "max" refers to the indicator with the lowest or highest actual value; "-" denotes that there is no DMU located in this area. I1 is the preparation of teaching contents; I2 is the teaching skills; O1 is the fair grading; O2 is the students' self-recognition of learning performance. Quadrant: I~IV are defined in Fig.1.

with their learning results. This implies that the other 48 DMUs are less satisfied about the acquired knowledge. Except for the grid of D37 and D41, all the other grids obtained their highest rating in preparation of teaching contents (max: I1) or in fair grading (max: O1). All the grids of efficient DMUs (BCC score=1) obtained their lowest rating in teaching skills (min: I2). This indicates that teachers need to improve their teaching skills in order to make the course contents easier to assimilate.

All the grids of inefficient DMUs (BCC score<1, Scale score <1) obtained their lowest rating in the teaching skills (min: I2) or in students' self-recognition of learning performance (min: O2). This means that students were less satisfied about the acquired knowledge. A total of 30 DMUs are located in the grids of (Inefficient DMUs, BCC score <Scale score, High or Medium groups). Their lowest ratings are all in O2 (students' self-recognition of learning performance), whereas their highest ratings are all in I1 (preparation of teaching contents). Relatively, a much bigger number of students believe that their teachers are working hard enough to prepare for their classes, and fewer students are satisfied with their learning performances. All the grids of the low group obtained their highest rating in fair grading (max: O1). This also means that they are less satisfied with their teacher's overall performance, but relatively more satisfied with teacher's grading criteria.

Application of the Management Matrix on Teaching Performance Improvement

This paper, inspired notably by Taylor *et al.* (2004), applied the original model of management matrix on teaching performance improvement and drew a matrix with 4 quadrants, as shown in Figure 1, according to our classification of DMUs under the BCC model detailed in Table 3. This proposed matrix can help DMUs to determine the quadrant they are located and to provide useful and practical information for educators and educational policy-makers who are responsible in designing teaching performance improvement measures.

The definition of the four quadrants is as follows:

Quadrant I:
- Efficient DMUs have BCC score=1, scale score=1, and belong to high or medium groups.
- Or efficient DMUs have BCC score=1, scale score<1, and belong to high group.

Quadrant II:
- Inefficient DMUs have BCC score<1, scale <1, and belong to high or medium groups.

Quadrant III:
- Inefficient DMUs have BCC score<1, scale <1, and belong to low group.

Quadrant IV:
- Efficient DMUs have BCC score=1, scale score=1, and belong to low group.
- Or efficient DMUs have BCC score=1, scale score<1, and belong to medium or low groups.

Suggestions for DMUs in each quadrant:

Quadrant I:
The DMUs are the most efficient. Educational policy-makers may establish a merit system to encourage teachers (i.e. best teacher award). As some students can not assimilate all the teaching contents (since scale score<1), teachers should avoid increasing its level of difficulty. Teachers may try to teach advanced courses so that students can benefit from their good teaching methods. The successful teachers may also help teachers in the other quadrants, notably by giving them advice or by inviting them to attend their classes occasionally.

Quadrant II:
DMUs have high ratings in students' evaluation, but the learning performance is lower than expected. Teachers need to improve their teaching contents and skills. For example, they can attend conferences on teaching performance or design E-learning and computer-assisted language learning. At the university studied in this paper, teachers can apply for creative teaching projects for a period of 1 or 2 semesters. These projects are financed by the Ministry of Education. Teachers are encouraged to redesign their courses and to propose creative new ideas to teach one of their courses. They can reapply every year. As a result, teaching efficiency and students' motivation and learning should improve.

Quadrant III:
DMUs have low ratings in students' evaluation. Students are less satisfied or more severe with their teachers. Teachers in this quadrant should be offered a chance to improve their ratings before being forced to teach other courses. They need to improve the teaching contents, their communication skills, and the atmosphere during the class (teamwork activities, interactive courses, role playing). Students who do not feel at ease during a class tend to give bad ratings to teachers, whatever the question asked.

Quadrant IV:
The DMUs are efficient but have low ratings in students' evaluation. This phenomenon can be explained by the fact that DEA estimates the efficiency frontier by the ratio of linear combination of inputs divided by the linear combination of outputs and measures the relative efficiency of each DMU (Author *et al.*, 2011). Teachers should not be satisfied with their efficiency. They need to improve their teaching and communication skills so that students can assimilate the course contents more easily. In addition, schools may provide teaching training as well.

In conclusion, the efficient DMUs in quadrant I need to maintain their performance level and may help teachers in the other quadrants by providing suggestions to the less efficient teachers. A fair, objective, and clearly defined merit system should be established to encourage DMUs in quadrant I. Meanwhile, the inefficient DMUs in quadrants II, III, and IV can emulate teachers in quadrant I and also make progress through the following suggested activities: teachers can apply creative teaching projects to redesign their courses; schools provide teaching training; learning new teaching skills; attending conferences on teaching and learning performances; giving performance alert for low rating; e-learning and computer-assisted language learning; designing attractive learning contents; interactive courses; teamwork activities, etc.

CONCLUSION AND SUGGESTIONS

The current work made use of DEA to explore two input indicators and two output indicators contributing to teaching performance at the university of Taiwan. The empirical results show that the average overall technical efficiency (the CCR score) of all the 50 DMUs is 0.962. D6, D22, D37, D41 and D49 have the best performance with a value of 1. These 5 efficient DMUs can serve as references for the other inefficient DMUs. The "Room for improvement" analysis indicates how much improvement is needed for the inefficient DMUs. For example, D23 (ranked 50) has the lowest overall technical efficiency of 0.906. This means there is still 10.3% improvement needed for fair grading and students' learning performances.

These results show that providing clear grading criteria at the beginning of the semester and guidance before the exams may increase students' motivation. Sometimes, too much effort in the preparation of teaching materials and course contents could confuse students and thus, have a negative impact on their learning performance. This is the case with D25 (ranked 6) and D3 (ranked 20). Some teachers who are used to teaching writing courses for senior students or graduate students need to adapt to the level of freshmen. Moreover, if they over-explain the course, it will probably make students feel bored and less attentive.

Using the results obtained with DEA model, this work proposed an original management matrix of DMUs' performance with 4 quadrants, which could help DMUs to determine the quadrant they are located in and to provide information for educational policy-makers who design management measures. The DMUs in quadrant I are the most efficient. They may be rewarded for their efforts and good performances. They can help their teachers in the other quadrants such as by giving them advice or by inviting them to attend their class occasionally. The DMUs in quadrant II have high ratings in students' evaluation, but the learning performance is lower than expected. These teachers can improve their teaching contents and skills, notably by applying creative teaching projects. The DMUs in quadrant III have the lowest efficiency and ratings. However, before they are forced to teach other courses (in the case university, part-time teachers with ratings lower than 3 can be fired), they should be offered a chance to improve their teaching performance. Other than that, the atmosphere during the class could be greatly improved by enhancing the teaching and communication skills. Moreover, when the ratings are low, students are rarely satisfied with the degree of preparation for the teaching contents. The DMUs in quadrant IV are efficient but have low ratings in students' evaluation. This is due to the fact that DEA measures the relative efficiency of each DMU. Teachers should not be satisfied with their efficiency and probably need teaching training. The results of the performance evaluation via the selected indicators can serve as a reference not only for educators, but also for the Ministry of Education to formulate educational policies.

ACKNOWLEDGEMENTS

The corresponding author would like to thank the National Science Council of the Republic of China (Taiwan) for financially supporting this research under contract no. 100-2914-I-126-012-A1.

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