A study on the quantitative analysis and evaluation of teaching quality for higher education institutions

Jihong Pang & Xiaojing Liu

Wenzhou University
Wenzhou City, Zhejiang, People's Republic of China

ABSTRACT: The aim of this article is to solve teaching quality evaluation problems within higher education institutions. However, the evaluation process includes complex analysis of teaching resources and the learning environment. As a result, it is very difficult to evaluate teaching quality accurately and quantitatively. The research carried out quantitatively analyses and evaluates the quality of teaching based on entropy theory and comprehensive evaluation methods. First, a theoretical framework was developed to quantitatively evaluate teaching quality. To measure the level of teaching quality in different environmental conditions, an evaluation model and procedure was designed. Based on the principles of fuzzy mathematics, the teaching quality evaluation model for higher education institutions was established. Then, the evaluation system of teaching quality was verified by the research data. The method based on entropy weight and fuzzy comprehensive evaluation was applied to attain the accurate results of teaching quality. Finally, the quantitative evaluating method and technique is presented, to estimate the teaching quality.

INTRODUCTION

Higher education institutions are advised to achieve considerable progress as the teaching market grows. Rapid economic development has meant the higher education system grew significantly during the past 20 years. So, the teaching quality of higher education institutions has become the most important factor in today's global economic and technical competition [1].

To meet the challenge of this global revolution, many higher education institutions worldwide are now increasingly focused on teaching quality [2]. The fact cannot be ignored that higher education is becoming more and more competitive. Higher education institutions have the potential to promote and encourage societal development.

A high quality teaching environment is currently achievable by optimising the teaching resources of colleges and universities [3]. Teaching quality is now an essential part of how higher education institutions are presented [4]. In order for different universities to compete successfully, there must be an improvement in education teaching quality [5]. As well, statistical data make it clear that higher education quality is most important for the leaders, teachers and students in college [6]. Students can benefit from the high-quality teaching provided by higher education institutions. How various resources are used within higher education to improve teaching quality is more important than ever [7].

To evaluate teaching quality scientifically and effectively is becoming more and more important as the number of universities and colleges is increasing year by year. What is perhaps most disconcerting is that the teaching quality within higher education institutions can be more accurately evaluated in many special ways [8]. In order to improve teaching quality, many teaching ideas and methods have been suggested and used in university teaching in recent years [9].

Therefore, it is very important for the university to strengthen teaching work and improve teaching quality [10]. At the same time, the university has faced considerable teaching challenges and opportunities. So, it is important to identify the great impact on teaching quality. More importantly, the quantitative analysis and evaluation of teaching quality for higher education institutions is gaining increasing importance [11]. It was highly apparent that to deal with these issues, teachers and students needed to be fully involved in the teaching processes of higher education institutions.

The goal of this article, authored by Jihong Pang of the College of Mechanical and Electronic Engineering at Wenzhou University, Zhejiang, PRC and Xiaojing Liu of the City College at Wenzhou University, Zhejiang, PRC, is to propose an innovative method to evaluate teaching quality and to improve the performance of higher education institutions. First, the related literature is reviewed in the following sections, and the methodology and procedure for evaluating teaching quality are discussed. Then, the innovative methodology of the study is presented. In the next section, these points are expanded through a case study on the teaching quality of Chinese higher education institutions. Finally, this

article ends with a conclusion, and a discussion of the results, with recommendations made concerning the use of the proposed approach.

THE APPROVED THEORETICAL FRAMEWORK

Many researchers evaluate the teaching quality of higher education institutions through qualitative and quantitative analysis. The accuracy and validity of traditional research depends on the ability of the researcher to explain the data collection methods available [12]. However, the details of how the evaluation process is carried out in different ways have not been clearly explained.

The authors' analysis in this article contributes to the extensive literature review [13]. Evaluating teaching quality at a university is a challenging process, and the enhancement of quality based on teacher and student evaluations must be regarded as a complex and important matter.

The evaluation procedure of teaching quality for higher education institutions includes the teaching environment, teaching management, teaching content, teaching innovation and teaching results. Once the evaluation criteria were identified through brainstorming sessions, the experts built the hierarchical structure of these criteria. The team members were given the task of forming an individual pair-wise comparison matrix of necessary weights. The evaluation model of teaching quality within higher education institutions is shown in Figure 1.
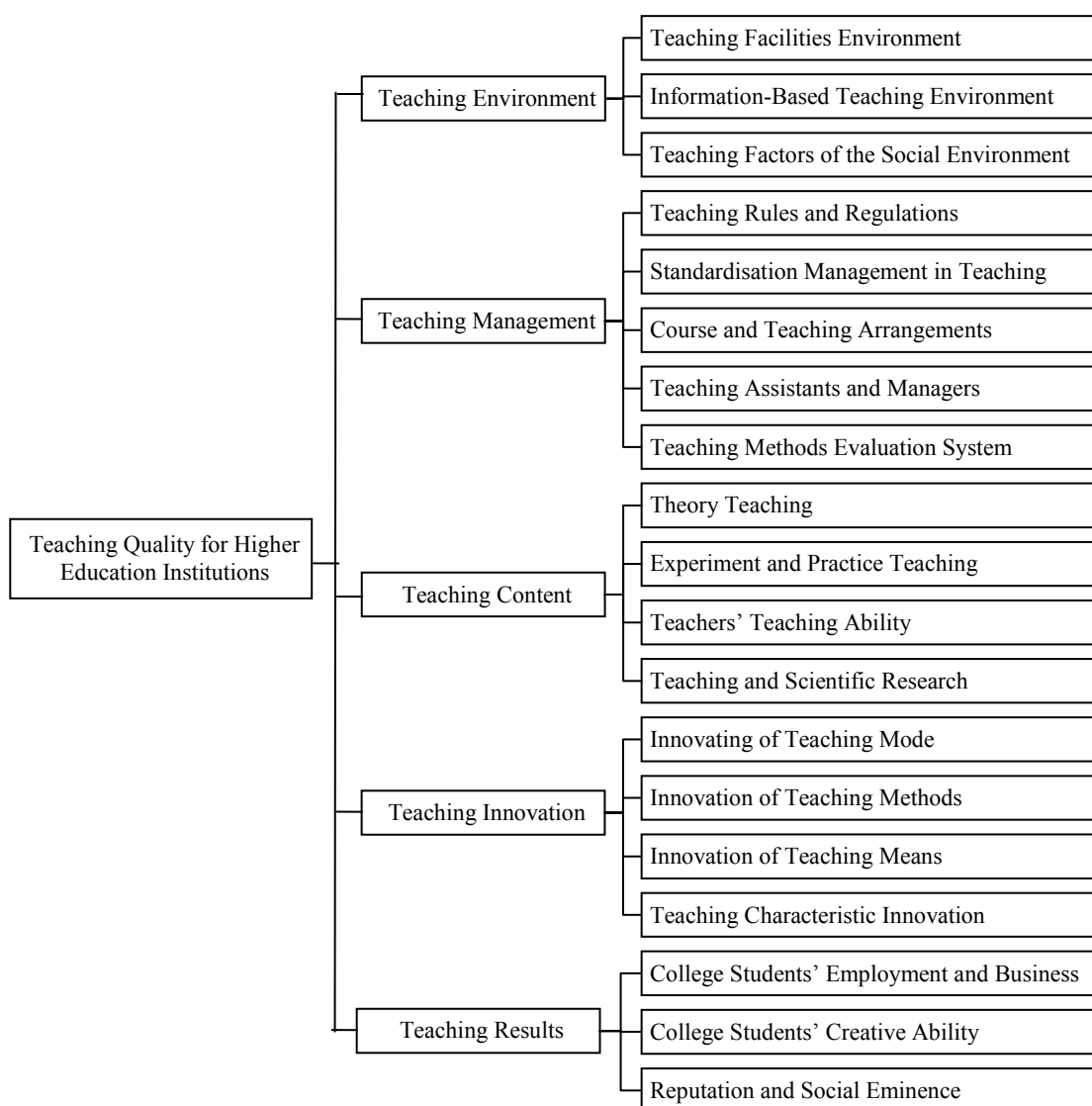

Figure 1: Evaluation model of teaching quality for higher education institutions.

Proposed in this article is the structured model of a teaching quality assessment system. The following sections detail each of these quality indicators.

1. Teaching Environment. To attract and train excellent teachers and students, a wide teaching environment must be constructed from macroscopic and microscopic aspects. Generally, the teaching environment is composed of three major sectors:

- Teaching Facilities Environment: In teaching activities, the teaching facilities environment must fully meet the needs of learners.
- Information-Based Teaching Environment: The teaching environment must combine multimedia information technology with appropriate teaching methods so as to promote well the college students' studying capability and teachers' professional skills.
- Teaching Factors of the Social Environment: The rationalisation and cultivation of teaching factors must be considered in a favourable societal environment.

2. Teaching Management. To enhance the efficiency of teaching activities and to be more satisfied with the work, the management of teaching should be arranged reasonably. The management of teaching can be divided generally into five major sectors:

- Teaching Rules and Regulations: Establishing and consummating a strict teaching management system. Policymakers, leaders, teachers and students at college should keep all the school rules and regulations.
- Standardisation Management in Teaching: Standardisation of the management of teaching at college must be maintained.
- Course and Teaching Arrangements: Teachers and students should follow the course arrangements and any reasonable requirement largely must be met.
- Teaching Assistants and Managers: The successful education system cultivates not only higher-qualified managers but also provides the college with higher-qualified assistants.
- Teaching Methods Evaluation System: To improve teaching quality, the teaching methods evaluation system also must be reformed.

3. Teaching Content. The teaching content for higher education institutions should be concise and modular. In general, the teaching content is composed of four major sectors:

- Theory Teaching: Positive results for teachers and students must be created using novel teaching theory and interactive teaching.
- Experiment and Practice Teaching: The experiment and practice teaching of content in a basic series course is very important and must combine the teaching of theory with the teaching of experiments.
- Teachers' Teaching Ability: In order to develop students' innovative abilities and creative ability in the teaching process, teachers at college must improve their teaching methods and strengthen their teaching ability.
- Teaching and Scientific Research: Universities and related departments must provide a range of basic and advanced equipment for research and teaching activities.

4. Teaching Innovation. A reasonable teaching system based on modern teaching theory and method should be built to maintain teaching innovation. In this case, the innovation of teaching has been broken down into separate components:

- Innovating of Teaching Mode: Teachers must be able to develop their own talents and abilities to generate and use knowledge to innovate in teaching.
- Innovation of Teaching Methods: The innovation of teaching methods is excellent assurance of improving the quality of higher education.
- Innovation of Teaching Means: As an innovator of means of management and teaching, the higher education institutions will give teachers and students a scientific and interactive teaching experience.
- Teaching Characteristic Innovation: The higher education system will note the implications of their characteristic innovative spirit and teaching style.

5. Teaching Results. In order to arouse students' enthusiasm for learning and to improve teaching results, the modern media and traditional teaching pattern must co-exist. The teaching results are split into the following sections:

- College Students' Employment and Business: The colleges must improve their policies to create employment, new job and business opportunities by constructing a college student's employment and business service support system.
- College Students' Creative Ability: The campus culture and teaching environment for students' growth will influence directly the development of creative thinking ability and creative ability.
- Reputation and Social Eminence: The college administrators may have considered, or should consider, the overall reputation and social eminence that will affect the ability to improve higher education.

RESEARCH METHODOLOGY

Considerable amount of research has been carried out on the quality of teaching within higher education institutions. A variety of studies have evaluated the quality of teaching by using different methods from different perspectives. The

entropy theory has been used successfully in a variety of fields [14]. In this article, the entropy weight combined with fuzzy comprehensive evaluation method was used, with statistics on the quality of teaching. This methodology includes the use of entropy theory and comprehensive evaluation method [15].

In order to evaluate teaching quality more accurately, a different matching technique based on entropy and comprehensive evaluation method was used. Beyond that, some implicit information on how data were collected and calculated is applied in this article. In addition, a strategy is proposed in this article to implement the evaluation and implementation of effective evaluation methods. The research method of entropy weight combined with fuzzy comprehensive evaluation is composed of ten steps:

Step 1: Standardisation of the decision matrix: The decision matrix can be normalised based on the research and defining the attribute matrix.

Step 2: Calculating the entropy.

The weight of each index can be calculated by making use of the entropy method. Based on the change of different entropy scale, the entropy can be quickly calculated as follows:

$$f_{ij} = y_{ij} \bigg/ \sum_{i=1}^{n} y_{ij} \tag{1}$$

Then, the entropy is expressed as follows:

$$e_j = -k \sum_{i=1}^{n} f_{ij} \ln f_{ij} \tag{2}$$

Step 3: Computing the weight factor.

The statistical theory is utilised to compute the weight factor of the measurement.

$$h_j = 1 - e_j \tag{3}$$

Step 4: Identifying entropy weight.

Based on the entropy weight method, the multi-level fuzzy synthesis evaluation model is established by identifying the indexes' entropy weight.

$$\alpha_j = h_j \bigg/ \sum_{i=1}^{n} h_j \tag{4}$$

Step 5: Building assessment index system.

The layered evaluation index system is established first. Then, the two level targets of the assessment system were defined by the following formula.

$$E_j = \left\{ E_{j1}, E_{j2}, \cdots, E_{ji} \right\} \tag{5}$$

Step 6: Building a comprehensive evaluation set.

The factor set and remarks set can be established based on the evaluation of an expert.

$$F = \left\{ F_1, F_2, \cdots, F_n \right\} \tag{6}$$

Step 7: Establishing the membership degree matrix.

While determining subordinate degree, the membership degree matrix was established based on the fuzzy set and its grade of membership.

$$H = \begin{bmatrix} H_{11} & H_{12} & \cdots & H_{1n} \\ H_{21} & H_{22} & \cdots & H_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ H_{m1} & H_{m2} & \cdots & H_{mn} \end{bmatrix} \tag{7}$$

Step 8: Determining comprehensive weight.

According to actual needs, the comprehensive weight can be determined by an integrated approach, such as the analytic hierarchy process, experts grading method, and so on.

$$W = \{W_1, W_2, \cdots, W_m\} \tag{8}$$

Step 9: Evaluating by using the multi-level fuzzy comprehensive method.

Fuzzy theory was applied to evaluate the gain and loss of the target. The membership vector matrix can be calculated by the following:

$$G_j = W_j \square H = (W_{j1}, W_{j1}, \cdots, W_{jn}) \begin{bmatrix} H_{11} & H_{12} & \cdots & H_{1n} \\ H_{21} & H_{22} & \cdots & H_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ H_{m1} & H_{m2} & \cdots & H_{mn} \end{bmatrix} \tag{9}$$

Step 10: Obtaining evaluation results.

The evaluation results can be obtained by the evaluative value.

$$V = W \bullet G \tag{10}$$

CASE STUDY OF TEACHING QUALITY EVALUATION FOR HIGHER EDUCATION INSTITUTIONS

College students are an integral part of educational institutions and they are the ones who will acquire the knowledge and skills in the education process. This study focused on information available through the public higher education institutions of China.

To ensure a representative sample, the authors selected and collected data of higher education institutions from various Chinese provinces such as Zhejiang, Jiangsu, Shandong, and so on. Data were, then, collected over a one-year period in 2011. In this article, the authors have established the teaching quality valuation system of higher education institutions and fuzzy membership degree in Table 1.

For example, the second index of teaching quality can be calculated as follows:

$$G_2 = W_2 \cdot H_2 = \begin{bmatrix} 0.103 \\ 0.095 \\ 0.224 \\ 0.156 \\ 0.422 \end{bmatrix}^T \begin{bmatrix} 0.8 & 0.1 & 0 & 0.1 & 0 \\ 0.6 & 0.2 & 0.1 & 0 & 0.1 \\ 0.5 & 0 & 0.2 & 0.2 & 0.1 \\ 0.2 & 0.2 & 0.5 & 0.1 & 0 \\ 0.1 & 0.3 & 0.2 & 0.3 & 0.1 \end{bmatrix} = (0.325 \ 0.187 \ 0.217 \ 0.197 \ 0.074)$$

Finally, the authors have calculated the total score by using Equation (10):

$$V = W \cdot H = \begin{bmatrix} H_1 \\ H_2 \\ H_3 \\ H_4 \\ H_5 \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.214 \\ 0.207 \\ 0.189 \\ 0.205 \end{bmatrix} \begin{bmatrix} 0.255 & 0.322 & 0.162 & 0.246 & 0.016 \\ 0.325 & 0.187 & 0.217 & 0.197 & 0.074 \\ 0.578 & 0.198 & 0.153 & 0.031 & 0.041 \\ 0.261 & 0.274 & 0.225 & 0.220 & 0.020 \\ 0.363 & 0.282 & 0.072 & 0.196 & 0.086 \end{bmatrix} = (0.360 \ 0.250 \ 0.165 \ 0.176 \ 0.049)$$

$E = V \cdot F = 0.360 \times 95 + 0.250 \times 85 + 0.165 \times 75 + 0.176 \times 65 + 0.049 \times 25 = 80.511$

From the above result, the authors have concluded that the teaching is *Very Good*. So, the methods are very effective based on the entropy weight combined with fuzzy comprehensive method.

Table 1: Teaching quality evaluation system of higher education institutions.

First-level indexes	Weights of first-level indexes	Second-level indexes	Weights of second-level indexes	Evaluation standard				
				Excellent	Very Good	Good	General	Bad
Teaching Environment	0.185	Teaching Facilities Environment	0.383	0.5	0.2	0.1	0.2	0
		Information-Based Teaching Environment	0.158	0.4	0.1	0.2	0.2	0.1
		Teaching Factors of the Social Environment	0.459	0	0.5	0.2	0.3	0
Teaching Management	0.214	Teaching Rules and Regulations	0.103	0.8	0.1	0	0.1	0
		Standardisation Management in Teaching	0.095	0.6	0.2	0.1	0	0.1
		Course and Teaching Arrangements	0.224	0.5	0	0.2	0.2	0.1
		Teaching Assistants and Managers	0.156	0.2	0.2	0.5	0.1	0
		Teaching Methods Evaluation System	0.422	0.1	0.3	0.2	0.3	0.1
Teaching Content	0.207	Theory Teaching	0.157	0	1	0	0	0
		Experiment and Practice Teaching	0.312	0.8	0	0.1	0.1	0
		Teachers' Teaching Ability	0.405	0.5	0.1	0.3	0	0.1
		Teaching and Scientific Research	0.126	1	0	0	0	0
Teaching Innovation	0.189	Innovating of Teaching Mode	0.231	0.6	0	0.2	0.2	0
		Innovation of Teaching Methods	0.197	0.3	0.1	0.3	0.2	0.1
		Innovation of Teaching Means	0.314	0.2	0.4	0.3	0.1	0
		Teaching Characteristic Innovation	0.258	0	0.5	0.1	0.4	0
Teaching Results	0.205	College Students' Employment and Business	0.412	0.3	0.3	0	0.3	0.1
		College Students' Creative Ability	0.136	0.1	0.5	0.2	0.2	0
		Reputation and Social Eminence	0.452	0.5	0.2	0.1	0.1	0.1

CONCLUSIONS

The analysis contained in this article takes account of policy developments and practical challenges for sustainable development in Chinese higher education institutions. Used in this research was the entropy weight combined with fuzzy and comprehensive evaluation method as a theoretical framework for estimating the quality of teaching for higher education institutions. This research is of importance for policymakers, researchers, teachers, students and educators. Moreover, policy makers know there is a deep connection between teaching quality and teaching resources under the restricted teaching environment.

The universities and educators must meet the needs of their students by improving their teaching quality. Further work on this theme will need to concentrate on adding more reference indicators in the evaluation process of teaching quality. The research is far from being perfect in practice, and further work is required.

REFERENCES

1. Keles, O., Evaluation of primary school students' thought about and behaviors and attitudes towards environment. *Energy Educ. Science and Technol. Part B-Social and Educational Studies*, 3, **3**, 343-358 (2011).

2. Al-Hawari, M. and Al-Halabi, S., The preliminary investigation of the factors that influence the e-learning adoption in higher education institutes: Jordan case study. *Inter. J. of Distance Educ. Technologies*, 8, **4**, 1-11 (2010).
3. Salman, M.N., The importance of sport of university students during campus life. *Energy Educ. Science and Technol. Part B-Social and Educational Studies*, 4, **1**, 495-500 (2012).
4. Iuliana, S., Adela, B., Radu, C., Razvan, Z. and Floarea, N., Improving organizational efficiency and effectiveness in a romanian higher education institution. *WSEAS Transactions on Computers*, 8, **10**, 1641-1650 (2009).
5. Agouridas, V. and Race, P., Enhancing knowledge management in design education through systematic reflection practice. *Concurrent Engng. Research and Applications*, 15, **1**, 63-76 (2007).
6. Al-Qirim, N., Determinants of interactive white board success in teaching in higher education institutions. *Computers and Educ.*, 56, **3**, 827-838 (2011).
7. Hamid, N.A.A. and Suberamany, R., IT/IS outsourcing relationship factors in higher education institution: Behavioral dimensions from client perspectives. *World Academy of Science, Engng. and Technol.*, 38, **3**, 841-850 (2009).
8. Geng, H. and Wu, C., An approach to evaluating the physical education teaching quality in colleges and universities with intuitionistic fuzzy information. *J. of Convergence Infor. Technol.*, 7, **14**, 368-374 (2012).
9. Ko, W-H. and Chiu, Y-H., Developing teaching quality indicators for the culinary teacher in a university. *World Transactions on Engng. and Technol. Educ.*, 9, **2**, 114-118 (2011).
10. Cicek, V. Ulker, R. and Tarman, B., Comparison of character education in US and Turkish educational systems: globalizing American education system. *Energy Educ. Science and Technol. Part B-Social and Educational Studies*, 4, **3**, 1311-1322 (2012).
11. Sun, M., Li, T., Ji, B., Jiao, Y. and Tang, S., Evaluation research on assessment of clinical nursing teaching quality based on fuzzy comprehensive evaluation method. *J. of Convergence Infor. Technol.*, 7, **8**, 82-91 (2012).
12. Wang, S. and Meng, X., Research on evaluation of teaching quality of university with triangular fuzzy information. *Inter. J. of Digital Content Technol. and its Applications*, 6, **15**, 201-207 (2012).
13. Arisholm, E., Briand, L.C. and Johannessen, E.B., A systematic and comprehensive investigation of methods to build and evaluate fault prediction models, *J. of Systems and Software*, 83, **1**, 2-17 (2010).
14. Chang, Y.C., Chang, K.H. and Liaw, C.-S., Innovative reliability allocation using the maximal entropy ordered weighted averaging method. *Computers and Industrial Engng.*, 57, **4**, 1274-1281 (2009).
15. Lu, J., Ma, J., Zhang, G., Zhu, Y., Zeng, X. and Koehl, L., Theme-based comprehensive evaluation in new product development using fuzzy hierarchical criteria group decision-making method. *IEEE Transactions on Industrial Electronics*, 58, **6**, 2236-2246 (2011).