Multivariate-combined teaching quality evaluation of engineering majors: taking Hebei University as an example

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ABSTRACT: As an educational mode introduced into the reform of engineering and technology education, the multivariate-combined teaching method (MTM) is supposed to improve the teaching quality and students' competitiveness. A research investigation based on a survey questionnaire and taking engineering majors at Hebei University as an example, was conducted to establish which factors have the strongest impact on the quality of teaching and how this method is viewed by the students. Specifically, the authors of this article endeavoured to analyse the influence of students' existing knowledge, the teacher's ability, teacher-student communication and learning opportunities, on the overall teaching quality using the analytic hierarchy process (AHP). The results demonstrate that the teachers' ability and students' existing knowledge have the greatest impact on teaching quality, while teacher-student communication and learning opportunities have shown lesser impact. The teaching effect survey shows that the majority of students are of the opinion that they benefit from the MTM.

INTRODUCTION

The multivariate-combined teaching method (MTM) is an educational mode that may be successfully applied in the reform of engineering and technology education and meets the need and desire of independent innovation. It can not only enrich and perfect education theory and offer constructive references for researchers in the related theory field, but also improve students' competitiveness and ability to solve practical problems [1]. Putting the MTM into effect contributes to encouraging students to join teaching activities positively, changing the passive situation that teachers just lecture and students just listen, mobilising the students' enthusiasm to study, improving the learning efficiency, making the class atmosphere easy, perfecting the teaching environment and broadening students' horizons [2].

Interesting results have been obtained when applying the MTM to teaching engineering majors at Hebei University in China. However, several problems in the teaching process that are worthy of further research and exploration still exist. For example, it is hard to reach the desired effect and the teaching goal owing to the limited ability of students, and teachers' ability cannot meet the needs of the MTM perfectly. There is a lack of appropriate communication between teachers and students that results in some students treating the MTM negatively and the University's authority has not attached enough importance to the MTM. All of these problems affect the implementation and perfection of the MTM for engineering majors at Hebei University.

In China, research efforts on the MTM mainly focus on the multivariate combination of different teaching methods, such as project teaching, practice teaching, bilingual teaching or unity-of-several-courses teaching, case study teaching, interactive instruction, network-aided instruction, and so on [3]. These methods are all widely used in engineering majors at Hebei University.

To fully understand the reasons why the MTM cannot achieve the goals expected of it, the authors adopted the analytic hierarchy process (AHP) [4] to examine the major causes that exert a significant influence on the teaching quality.

The basic idea behind the AHP is to break complex problems up into several levels. At the lowest level, one can find the weight of each factor by comparing two different factors separately and on basis of the from-low-to-high hierarchical analysis calculation, one can obtain a final weight for each programme to the ultimate goal. The one with the biggest weight has the highest impact.

RESEARCH SUBJECTS

The target research subjects were the undergraduates and postgraduates students of different grades and majors at the School of Civil Engineering and Architecture of Hebei University. A total of 310 questionnaires were sent out and 303

were returned. Among those, 297 were valid for analysis, 175 of which were from undergraduates and 122 from postgraduates.

The questionnaire consists of a brief introduction and the main body of text. The main body of text comprises information on the research subjects' background and the matter for investigation. There are seven parts in the main body, which are questions on project teaching, practice teaching, bilingual teaching or unity-of-several-courses teaching, case study teaching, interactive instruction, network-aided instruction and questions on the extent to which the teaching goals are achieved.

MULTIVARIATE-COMBINED TEACHING METHOD QUALITY EVALUATION BASED ON HIERARCHICAL ANALYSIS METHOD

Establishment of the Hierarchical Structure Model

When analysing problems using the analytic hierarchy method, a complex problem should be organised and layered, and a hierarchical structure model should be established. In undertaking the study, the authors divided the model into three levels: the highest level (the *target level*), which contains only one element i.e. the teaching mode, and it is the expected goal of the problem that the authors analyse; the middle level (the *rule level*), which contains the rules involved to reach the target; and the lowest level (the *measure level* or *plan level*), which includes all the alternative plans for the project under study [5].

In the daily life teaching process, the commonly-used teaching methods include practice teaching, bilingual teaching, case study teaching, interactive instruction, network-aided instruction, traditional teaching method, and so on. The teaching quality is affected by several factors, which include students' basic knowledge, the teacher's ability, information exchange between teacher and student, whether student get enough study opportunities, etc. From this, one can establish a hierarchical analysis model based on the above theory (see Figure 1).

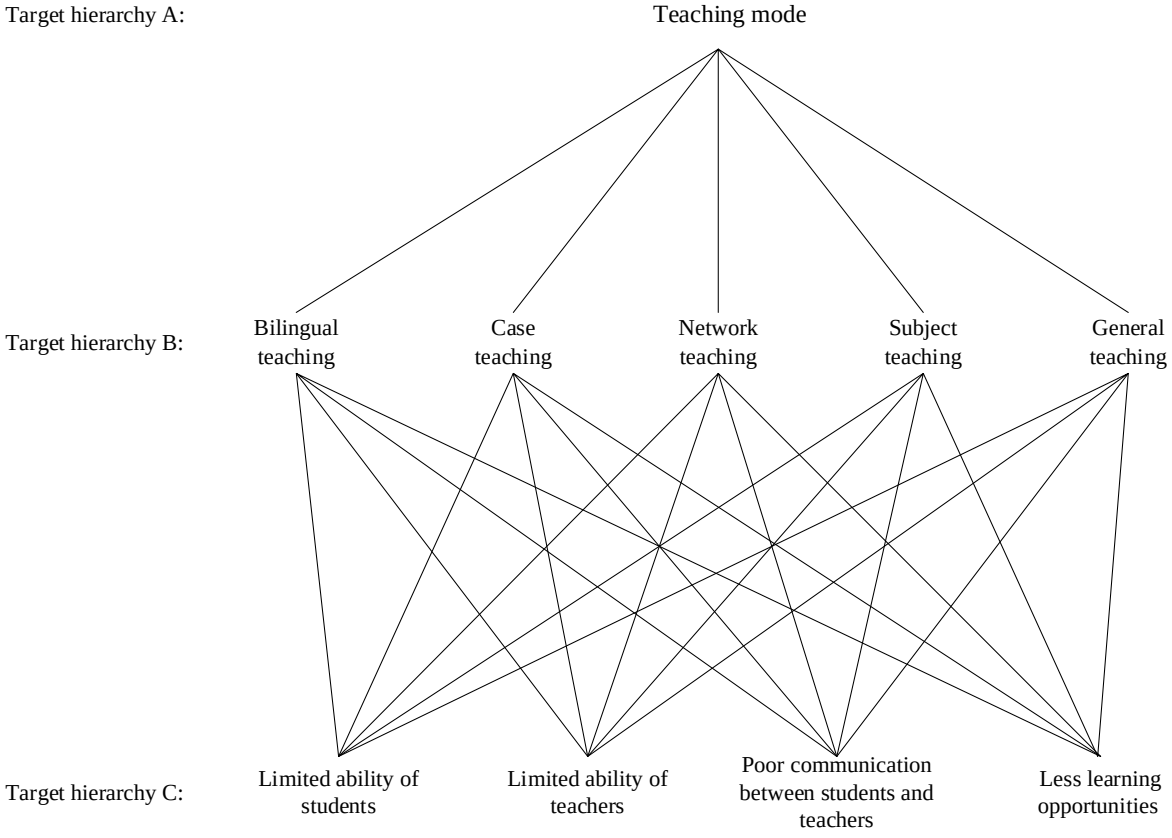

Figure 1: A hierarchical analysis model of teaching quality evaluation.

Construct the Judgment Matrix

The judgment matrix, the core of the analytic hierarchy process can be obtained by comparing two different factors respectively. That is to say, when comparing how much the factor X will affect a certain factor Z, one can extract two factors, x_i and x_j, then, defining a_{ij} as the ratio of x_i' impact on Z and x_j' impact on Z. All the comparison results can be represented by the judgment matrix between Z and X, $A = (a_{ij})_{n\times n}$ [6]. The a_{ij} in the judgment matrix is determined as shown in Table 1. Then, in accordance with the AHP process, one can compute the judgment matrix.

Table 1: Determination of all the elements in the judgment matrix.

Arbitrary scale	Implication
1	Compared with two factors, they are of equal importance
3	Compared with two factors, the former is slightly more important than latter
5	Compared with two factors, the former is obviously more important than latter
7	Compared with two factors, the former is strongly more important than latter
9	Compared with two factors, the former is extremely more important than latter
2，4，6，8	Intermediate value of the above adjacent judgment
Inverse	Supposing that a_{ij} denotes the ratio of the importance of factor i and the importance of j, the ratio of the importance of j and the importance of factor i is: $a_{ji} = \frac{1}{a_{ij}}$.

Calculation of the Eigenvalues of the Judgment Matrix and the Consistency Test

Based on the judgment matrices, one can find the biggest eigenvalue of each matrix with the eigenvector method and, then, conduct a consistency test.

The consistency test shows that the consistency ratio of all judgment matrices is less than 0.1, which means that all of the judgment matrices pass the consistency test.

Finding the Weight Matrix between the Hierarchies

With the eigenvector method, one can obtain the weight matrix between the hierarchies when obtaining the eigenvalue and the consistency ratio.

$$W^A = (0.222 \quad 0.222 \quad 0.222 \quad 0.222 \quad 0.111)$$

$$W^B = \begin{bmatrix} 0.301 & 0.509 & 0.127 & 0.062 \\ 0.233 & 0.140 & 0.542 & 0.085 \\ 0.351 & 0.351 & 0.189 & 0.109 \\ 0.192 & 0.129 & 0.071 & 0.608 \\ 0.186 & 0.532 & 0.186 & 0.097 \end{bmatrix}$$

The total weight of the degree to which various factors are having effects on the teaching quality affect teaching methods can be found with the formula: $W = W^A W^B$:

$$W = (0.222 \quad 0.222 \quad 0.222 \quad 0.222 \quad 0.111) \begin{bmatrix} 0.301 & 0.509 & 0.127 & 0.062 \\ 0.233 & 0.140 & 0.542 & 0.085 \\ 0.351 & 0.351 & 0.189 & 0.109 \\ 0.192 & 0.129 & 0.071 & 0.608 \\ 0.186 & 0.532 & 0.186 & 0.097 \end{bmatrix}$$

$$= (0.260 \quad 0.310 \quad 0.227 \quad 0.203)$$

This means that among various teaching methods, the ability of teachers affects teaching quality most, followed by the ability of students. Teacher-student communication and learning opportunities also have effects; however, their impacts are less than the first two.

TEACHING EFFECT EVALUATION

In this investigation, the authors asked students about their attitude toward the MTM. It shows that more than 80% of the students think it was helpful to implement the MTM. Of the students, 80.60% thought that bilingual teaching was necessary, and more than 90% of them thought that project teaching, practice teaching, unity-of-several-courses teaching, case study teaching, interactive instruction and network-aided instruction were necessary for their study.

Most students have taken part in the multivariate-combined teaching course. Students' attitudes towards each method are presented in detail in Table 2.

Table 2: Students' attitude towards the MTM (%).

Teaching method	Project teaching	Practice teaching	Bilingual teaching	Case study teaching	Interactive instruction	Network-aided instruction	Average
Necessary	94.65	97.32	80.60	94.65	96.32	91.64	92.53
Needless	5.35	2.68	19.40	5.35	3.68	8.36	7.47
Having taken part in	15.05	45.15	60.20	61.20	62.54	61.54	47.55
Never taken part in	84.95	54.85	39.80	38.80	37.46	38.46	52.45

The authors also surveyed students about the effectiveness of the MTM. Since the sample size of students who have taken part in the project and practice teaching course involved in the survey was small, the authors asked some additional, complementary questions about these two teaching methods to enhance the validity of the survey.

For the project teaching and practice teaching, 15.05% of the students took part in the project teaching course, and 45.15% of them took part in the practice teaching course. Most of the students actively participated in the project or practice; however, some students only participated after their supervisors asked them to do so. The investigation shows that by responding *never taken part in* does not mean that the students do not have the desire to take part in the future. In fact, more than 70% of the students who did not take part in the project or practice teaching course, responded that they have the desire, only without action. The detailed information concerning this matter is shown in Table 3.

Table 3: Survey results on project teaching and practice teaching (%).

Students' answers	*Having taken part in*		*Never taken part in*			
	Active participation	Supervisor asked	No desire	Think it is useless	Desire without action	Others
Project teaching	64.44	35.56	7.48	3.94	72.83	15.75
Practice teaching	91.11	8.89	10.36	3.66	71.95	14.02

With regard to bilingual teaching, unity-of-several-courses teaching, case study teaching, interactive instruction and network-aided instruction, 49.11% of the students thought that these teaching methods were of great help; 46.77% of the students thought that they were helpful, and only 4.13% of the students thought that they were useless. More details are shown in Table 4.

Table 4: Teaching effect survey of the MTM (%).

Students' answers	Of great help	Helpful	Useless
Bilingual teaching	36.13	57.98	5.88
Unity-of-several-courses teaching	46.88	51.88	1.25
Case study teaching	58.47	38.80	2.73
Interactive instruction	51.34	42.25	6.42
Network-aided instruction	52.72	42.93	4.35
Average	49.11	46.77	4.13

From the survey results, the authors found that most students thought that it was necessary for the universities to conduct teaching method reform and implement the MTM. Nearly half of the students took part in the multivariate-combined teaching courses, and more than 90% of them benefited from it.

CONCLUSIONS

On the basis of the above analysis of various factors that affect the teaching quality, the authors have come to the conclusion that the MTM, when compared with the traditional teaching methods, can considerably enhance the learning enthusiasm of students, make the class atmosphere easier and, generally, improve the teaching efficiency.

Of the four factors, which affect the teaching quality, teachers' ability has the greatest impact, while opportunities for students to participate in class have a lesser impact. It was found that the importance of influential factors of teaching quality differed between teaching methods. Only in the project teaching, opportunities that students can take part in have the strongest effect on teaching quality, yet it has little impact in other teaching methods. The teaching effect survey shows that most of the students benefited from the MTM.

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