Research on the Construction of Teaching Evaluation System of Mathematics Courses at Applied Undergraduate Colleges in the Context of New Engineering

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Abstract. The proposition of "New Engineering" has guided the new direction of talent training at colleges and universities and also put forward new requirements for the teaching of college mathematics. According to the cultivation characteristics of applied undergraduate colleges and the requirements of new engineering training, this paper constructs a teaching evaluation system with mathematics literacy and practical ability as the training objectives. It is pointed out that in the context of "new engineering" and in the teaching process of mathematics courses in applied undergraduate colleges, teachers should be guided to focus on teaching content reform, strengthen practical teaching, highlight ability training, and pay attention to teaching assessment, so as to promote the development of students.

Keywords: New engineering · College mathematics, teaching evaluation system · Layered analysis method

1 Proposition of Problems

In recent years, the new industrial revolution has accelerated, the globalization process has deepened, the new economy has accelerated, and the modernity situation has become more complicated. China's engineering education has responded in a timely manner. The proposition of "new engineering" is an inevitable outcome of the development of science and technology.

According to the statistics of the "Manufacturing Talent Development Planning Guide" jointly issued by the Ministry of Education, the Ministry of Human Resources and Social Security, and the Ministry of Industry and Information Technology, by 2020, a new generation of information technology industry, power equipment, high-end CNC machine tools and robots, new materials will become the largest professional gap. Nowadays, only the next-generation information technology industry represented by big data, artificial intelligence, and cloud computing has a talent gap of 1.5 million. By 2050, the talent gap will reach 9.5 million. Training "new engineering" is a top priority for university education.

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In the core competence of new engineering students, mathematics is the core of knowledge. The ability to apply math, science, and engineering knowledge to solve problems is a key skill for new engineering students [1]. However, there are many difficult factors in the reform and development of university mathematics. For example, the teaching ideas are old, only the basic teaching and the lack of mathematics practice; the teaching content is difficult to understand, the teaching results are more important in the teaching, and the cultivation of mathematical thinking is lighter; the mathematical structure of the mathematics is unchanged, and there is very little integration with the profession; the practical ability of the teacher engineering is weakened, and the mathematics teachers lack professional background. The mathematical structure of the mathematics is unchanged, and there is very little integration with the profession; the practical ability of the teacher engineering is weakened, and the mathematics teachers lack professional background.

Therefore, in the context of informationization, digitization, intelligent new situation and the construction of "new engineering", college mathematics as a basic discipline of engineering education must also make timely changes to meet the needs of professionals and the cultivation of talents. Timely and in-depth study of the undergraduate students' changes in mathematics knowledge and ability, exploring the reconstruction of the university mathematics curriculum system and the reform of teaching content has become the cornerstone of the "new engineering" talent training.

Under the requirements of the "New Engineering", the application of undergraduate mathematics teaching reform is imminent. The school should combine the application-oriented talent training orientation and the professional training requirements to study and formulate the university mathematics teaching evaluation system, so as to guide the teaching activities of teachers and students, cultivate students' mathematical literacy and improve students' mathematics practice ability. Moreover, this can promote student development to meet the needs of employment and social talent.

2 Research Process and Method

2.1 Principles for Evaluating the Construction of Indicator Systems

First, the principle of being scientific.

Through investigation and analysis, the evaluation indicators are basically in line with the objective reality, and can objectively and truly reflect the teaching characteristics and current situation of mathematics in applied undergraduate colleges. Therefore, it is necessary to avoid random, contingent, and subjective evaluations.

Second, the principle of being systematic.

There is a certain logical relationship between the indicators. They reflect the role and connection of university mathematics teaching in the quality training and practical ability of students from different aspects. The indicators are independent of each other, and they are connected with each other. The level is clear. From top to bottom, from macro to micro, an indivisible evaluation system is formed to form a true and systematic evaluation of college mathematics teaching.

Third, the principle of being classic.

This evaluation system has a certain typical representativeness. It reflects the characteristics of "new engineering" and "applied undergraduate" as much as possible. The setting of the evaluation indicators and the formation of the judgment matrix in the system all reflect the above two characteristics.

Fourth, the principle of being operative and quantified.

The selection of each indicator is consistent within the overall scope, which is convenient for decomposition, assessment and evaluation, and is convenient for practical operation. The indicators are consistent in terms of calculation metrics and calculation methods.

Fifth, the principle of being dynamic.

The selection of each indicator can be reflected by a certain time scale, and the research method of the problem facilitates the replacement of indicators and data, thus facilitating the sustainability study of the teaching evaluation system.

2.2 Layered Analysis of the Establishment of Evaluation Indicators

(1) Constructing Teaching Evaluation Indicator System

The layered analysis method was proposed by T.L. Saaty, an American operations research expert and professor at the University of Pittsburgh. This method can be used to determine the weight of each indicator and to prioritize the rated objects.

Combined with the research results of mathematics curriculum construction in relevant applied colleges [2–4], considering the requirements of "new engineering" and the characteristics of training talents in applied undergraduate colleges [5–8]. It is necessary to follow the principles of science, system, typicality, operability and quantifiability, and dynamics, aiming at cultivating students' literacy and practical ability. From the four aspects of teaching team, classroom teaching, class activities, teaching evaluation and feedback, the indicators are refined, and the indicators of the teaching evaluation system of mathematics courses in applied undergraduate colleges under the background of "new engineering" are analyzed as follows. The structure of the teaching evaluation index is shown in Table 1 below:

Table 1. Teaching evaluation indicators and their codes and descriptions

Primary indicators	Secondary indicators	Evaluation contents
Teaching team A_1	Education and title B_{11}	Teachers' teaching level, academic level, classroom organization and management ability
	Double-teacher B_{12}	"Double-teacher" teacher ratio, teacher enterprise and industry practice experience

(*continued*)

Table 1. (*continued*)

Primary indicators	Secondary indicators	Evaluation contents
Classroom teaching A_2	Teaching preparation B_{21}	Pre-testing, instructional design, and teaching resource preparation
	Teaching contents B_{22}	The depth, breadth, and degree of integration of the content of the teaching
	Teaching methods and means B_{23}	Teaching methods are diverse and teaching methods serve the purpose of teaching
	Teaching activities B_{24}	Students' subjectivity
Extracurricular activities A_3	Independent learning B_{31}	MOOC and other independent learning
	Mathematical activity B_{32}	The situation of mathematics activities involved under the guidance of teachers, such as mathematical modeling, mathematics competition, etc.
Teaching evaluation and feedback A_4	Evaluation of teachers B_{41}	Evaluation of the teaching content, design, assessment and organization of the teacher's activities
	Evaluation of students B_{42}	The degree of completion of the process assessment and final assessment

(2) Construct the judgment matrix:

Layered analysis is used to determine the weight of indicators at all levels. In this paper, the level of the same level index relative to the upper level index is assessed by a pairwise comparison [9]. The role of the judgment matrix is to compare the order of the same level indicators under the constraints of an indicator of the previous layer. Generally, the indicators of the pairwise comparison are assigned by referring to the table of the relative importance level of Table 2, and a judgment matrix (i.e., an importance level table) is formed.

Table 2. Star relative importance rating table

Relative importance	Equally important	Slightly important	Obviously important	Strongly important	Extremely important	Between the two extremes
Grade	1	3	5	7	9	2,4,6,8
Relative importance	Equally non-important	Slightly non-important	Obviously non-important	Strongly non-important	Extremely non-important	Between the two extremes
Grade	1	1/3	1/5	1/7	1/9	1/2,1/4,1/6,1/8

Based on the interviews and questionnaire surveys of teachers and students in applied undergraduate colleges, the paper obtains the judgment matrix of the first-level indicators and the second-level indicators in Table 1, which are as follows:

Table 3. Primary indicator judgment matrix

	A_1	A_2	A_3	A_4
A_1	1	1/8	1/4	1/3
A_2	8	1	3	4
A_3	4	1/3	1	1
A_4	3	1/4	1	1

Table 4. Secondary indicator judgment matrix

	B_{11}	B_{12}
B_{11}	1	1/3
B_{12}	3	1

	B_{21}	B_{22}	B_{23}	B_{23}
B_{21}	1	1/6	1	1
B_{22}	6	1	5	4
B_{23}	1	1/5	1	1/5
B_{23}	1	1/4	2	1

	B_{31}	B_{32}
B_{31}	1	1/5
B_{32}	5	1

	B_{41}	B_{42}
B_{41}	1	3
B_{41}	1/3	1

Record the above judgment matrix in turn as A, B_1, B_2, B_3 and B_4.

(3) Calculation of Weights

Step 1: Normalize elements of the judgment matrix $A = \det(a_{ij})$ to get the matrix $B = \det(b_{ij})$, in which

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} (i,j = 1,2,\cdots,n)$$

Step 2: Cumulate elements in matrix B to get the vector $C = (c_1, c_2, \cdots, c_n)^T$, in which

$$c_i = \sum_{j=1}^{n} b_{ij} (i,j = 1,2,\cdots,n)$$

Step 3: Normalize vector C to get the featured vector $W = (w_1, w_2, \cdots, w_n)^T$, in which

$$w_i = \frac{c_i}{\sum_{k=1}^{n} c_k} (i,j = 1,2,\cdots,n)$$

It is the weight of each indicators at this layer.

Step: Get the maximum featured root $\lambda_{\max}$:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)}{w_i} (i,j = 1,2,\cdots,n)$$

After calculation, the featured vectors of the judgment matrixes A, B_1, B_2, B_3 and B_4 can be obtained as follows:

Besides, according to the judgment matrix provided in Tables 3 and 4, and after calculation, the maximum featured roots of the judgment matrixes A, B_1, B_2, B_3 and B_4 can be obtained as follows:

(4) Consistency test

Due to differences in people's understanding, the above judgment matrix may not be consistent. To this end, we use a random consistency ratio to test the degree of deviation, and introduce the calculation formula and random consistency indicators here:

$$CR = \frac{CI}{RI},$$

In which, CI is the consistency index,

$CI = \frac{\lambda_{max}-n}{n-1}$ (the larger CI is, the more inconsistent it is);

RI is the average random consistence indicator as shown in the following Table 5:

Table 5. Random consistency indicator RI

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Define the consistency ratio: when $CR \leq 0.1$, it can be considered that the judgment matrix has consistency, that is, the weight is valid; when $CR > 0.1$, it can be considered that the judgment matrix deviation is too large, and the score needs to be revised again until there is consistency.

With the maximum eigenvalue of each judgment matrix obtained in (3), the random consistency indicators CR of A, B_1, B_2, B_3 and B_4 are 0.0038, 0, 0.0215, 0 and 0. Each value is less than 0.1, which means that the degree of inconsistency of the above judgment matrix is within the allowable range, that is, the weight distribution of each level of indicators is very reasonable.

(5) Overall ranking calculation of secondary indicators

The ranking method of the secondary indicators is: the product of the weight of each indicator in the layer and the weight of the corresponding upper layer indicator. For example, the ranking weight of B_{11} (education and title) is the sum of the first dimensional vector $W_1 = (0.25, 0.75)$ in $W = (0.0579, 0.5465, 0.2163, 0.1793)$, i.e., 0.0579×0.25.

Applying the above calculation method, the overall ranking of teaching evaluation indicators can be obtained, as shown in Table 6.

Table 6. Overall ranking of secondary indicators

Secondary Indicators	Primary indicators				Overall ranking of secondary indicators	Rank
	A_1	A_2	A_3	A_4		
	0.0579	0.5465	0.2163	0.1793		
B_{11}	0.25				0.0145	10
B_{12}	0.75				0.0434	8
B_{21}		0.1213			0.0663	5
B_{22}		0.6126			0.3348	1
B_{23}		0.1034			0.0565	6
B_{24}		0.1627			0.0889	4
B_{31}			0.1667		0.0361	9
B_{32}			0.8333		0.1803	2
B_{41}				0.25	0.0448	7
B_{42}				0.75	0.1345	3
$\sum$	1.00	1.00	1.00	1.00	1.00	

2.3 Result Analysis

According to Table 6, from the evaluation results of the overall ranking of the secondary indicators, the weight indicator of (teaching contents) ranks the first. And the weight value is much higher than other indicators. This shows that in the context of "new engineering", the mathematics teaching of applied undergraduate colleges should pay special attention to the arrangement of teaching content. The weight indicator of (mathematical activity) ranks the second, which indicates that it is urgently needed for students to carry out relevant mathematical modeling and mathematics competitions under the class. This will greatly help to improve students' mathematics practice ability. The weight indicator of (evaluation of students) ranks the third. This shows that in the teaching process, the process evaluation and the final evaluation are very important components of teaching, and it plays an important role in promoting the evaluation of teaching [10].

In addition, it can be seen from Table 6 that the weight indicator of (double teacher) is higher than that of (education and title). This shows that at applied undergraduate colleges, teachers' business and industry experience are more important than academic qualifications and titles.

3 Conclusion

Faced with the new requirements of "New Engineering" for mathematics teaching in applied undergraduate colleges, teachers should actively update their understanding of the mathematics teaching evaluation system. In addition, teachers should pay attention to the adjustment of teaching content, to meet the cultivation of applied talents, and to pay attention to the combination of knowledge and professionalism. It is necessary to pay attention to the practical teaching of university mathematics, improve the cognitive ability of students' mathematical knowledge, use mathematics to conduct mathematical experiments, and solve practical professional problems. It is necessary to pay attention to the assessment of students' ability, enrich the assessment methods and assessment content, and the learning attitude, hands-on ability and innovative spirit are all important basis for evaluation. At the same time, teachers should pay attention to their own development. While upgrading their academic qualifications and professional titles, they will consciously enter relevant enterprises, understand the application of mathematics in the industry, and guide students to study mathematics in college.

With the advancement of science and technology and the development of professionalism, the evaluation system of mathematics teaching in universities is constantly changing and changing. Teachers should adjust the evaluation system in a timely manner according to the development requirements of students, so as to better complete the training of students.

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