Optimization of the Indicator System for Students' Evaluation of Teaching in Universities Based on the AHP Method

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Abstract. Students' evaluation of teaching is an important part of education evaluation and is currently one of the main means of feedback on university teachers' quality of classroom teaching. However, there are three problems with the current indicator system for students' evaluation of teaching: inappropriate system design, lack of pertinence, and lack of qualitative evaluation. Optimizing the indicator system can help solve the aforementioned problems and thus improve the quality of teaching management, promote the professional development of teachers, thereby enhancing the quality of talent training.

Keywords: Students' evaluation of teaching · indicator system · optimization

1 Introduction

1.1 The Indicator System is Inappropriately Designed and Diverges from the Perception of Teachers and Students

From the professional perspective in pedagogy and educational statistics, numerous researchers have used various methods to formulate a representative indicator system for classroom teaching that meets the professional requirements of pedagogy and educational statistics, which has gradually formed a system for students' evaluation of teaching which includes primary and secondary indicators. However, the subjectivity of teachers and students was not fully reflected in the process. For instance, the preparation of primary and secondary indicators did not fully consult teachers and students. As a result, students are asked to evaluate whether the course content is up-to-date and innovative and whether the teacher's basic teaching skills are solid, which are clearly beyond students' capabilities. Moreover, the weight design of the indicator system is not scientific enough, as different indicators are assigned the same weight. To illustrate, the equal weight of teaching methods and teaching effectiveness among the primary indicators neglects the output result orientation of education and teaching. The shortcomings of the indicator system design and the low participation of teachers and students in the preparation process have resulted in a divergence from teachers' professional perspectives and a lack of attention and respect that students deserve.

1.2 The Indicator System is Overly Unified and Lacks Pertinence

By studying the indicator systems published online by various universities, it is found that the indicator systems of different universities share many similarities. Different universities have applied and borrowed the indicator system from each other without conducting targeted design based on the universities' respective education levels and teaching characteristics, which also leads to the wide spread of defects in the design of the indicator system [1]. Also, the indicator systems for teaching evaluation for different disciplines of the same university lack pertinence. For example, in the indicator system, "The teacher has a clear teaching purpose, reasonably arranges the structure and content of classroom teaching, and chooses appropriate teaching methods" is too broad and does not distinguish between disciplines, which fails to meet the requirements of reflecting disciplinary characteristics. Consequently, different disciplines share the same indicator system, and theory and practice classes share the same evaluation form. The design of the indicator system should adhere to the principle of combining commonality and individuality. The indicators can be extracted from common factors affecting teaching effectiveness and thus be widely applied to different universities and majors. The individuality indicator should be designed in a targeted manner according to the requirements of specific universities and majors.

1.3 The Indicator System Focuses Mainly on Quantitative Assessment and Lacks Qualitative Evaluation

The existing indicator system shows a trend of discarding subjective and qualitative judgment and emphasizing objective and quantitative scoring. After studying the indicator systems of 23 colleges and universities randomly selected on the Internet, we found that the indicator systems of these 23 colleges and universities compose mainly of quantitative questions, with only one qualitative question, i.e., "opinions and suggestions". The qualitative question is rarely set, and the question orientation is broad and lacks pertinence. A more ideal indicator system should focus on both quantitative measurement and qualitative description and attach importance to the organic combination of quantitative analysis and qualitative research, so as to provide effective data support for teaching construction.

2 Value Orientation of the Optimization of the Indicator System for Students' Evaluation of Teaching

2.1 Serving to Enhance the Quality of Talent Training

The optimization of the indicator system for students' evaluation of teaching will consider student-centeredness a core philosophy. Currently, some students do not have a clear understanding of students' evaluation of teaching and regard it as an extra burden, thus performing teaching evaluation arbitrarily. The fundamental cause of such phenomena is that students' participation is not strong in the whole process of students' evaluation of teaching, and their subject status in the process is not guaranteed. Accordingly, they play a passive role in teaching evaluation [2]. With a view to optimizing the indicator system

for students' evaluation of teaching, by taking into account the subject status of students, students' understanding of students' evaluation of teaching will be transformed, their enthusiasm to participate will be greatly boosted, and the evaluation results will be more scientific. Furthermore, it facilitates the opening of a student-centered teaching mode, helps to mobilize students' learning autonomy and enthusiasm, promotes students' collaborative learning ability and hands-on practical ability, and improves the quality of talent training.

2.2 Serving to Promote the Professional Development of Teachers

"The existence of university teachers connects people, disciplines, and universities in higher education. Among the personal development of teachers, discipline development, and university development, the personal development of teachers comes first, as it covers teaching development, research development, and human development [3]." As an important link in the quality assurance of teaching in universities, students' evaluation of teaching is of great significance to teachers' professional development.

Students' evaluation of teaching focuses on developmental evaluation that meets the needs of teachers' long-term personal development and attaches importance to the differences between teachers and between subjects to meet teachers' personalized needs by setting diversified and personalized measurement criteria. Meanwhile, as different evaluation subjects such as students and peer teachers make evaluations, their evaluation opinions corroborate and complement each other, which can ensure the objectivity and accuracy of evaluation results. Through standardized students' evaluation of teaching, on one hand, teachers can discover their strengths and weaknesses, which can awaken their intrinsic development needs and stimulate their development awareness and potential. On the other hand, students' evaluation of teaching can provide teachers with external stimulation, exert some pressure on them, and enhance the pressure and motivation for their development [4]. It can promote the process of continuous self-cognition, self-reflection, and self-development in the evaluation process and help teachers refine their teaching practice.

2.3 Serving to Improve the Quality of Teaching Management

For the teaching management department, a clear understanding of the actual situation of education and teaching carried out in universities is a prerequisite for strengthening the management and monitoring of teachers' teaching quality. Students' evaluation of teaching collects and collates teachers' teaching information through multi-party collaboration to achieve the evaluation purpose, thus optimizing the indicator system for students' evaluation of teaching to make it more scientific and standardized [5]. The teaching management department can strengthen the monitoring and management of the teaching process at the macroscopic level by analyzing and managing the results of students' evaluations of teaching. At the microscopic level, the teaching management department can optimize the teaching plan and curriculum structure, correct the deviation in teaching management and improve the specificity and pertinence of teaching

management. In this way, students' evaluation of teaching can make teaching management more scientific and effective as a whole, and realize the steady improvement of teaching management quality.

3   Construction of an Indicator System for Students' Evaluation of Teaching

Based on the optimization analysis of the existing indicator system, the Analytic Hierarchy Process (AHP) can be used to conduct further fuzzy quantitative analysis. With the indicator system for students' evaluation of teaching in universities as the target level, the six dimensions of teaching content, teaching ability, teaching methods, teaching effectiveness, teacher ethics and morals, and information resources constitute the primary indicators, and 21 secondary indicators such as the pertinence of teaching content are further specified. The model of the evaluation indicator system is shown in Table 1.

Table 1. Indicator System for Students' Evaluation of Teaching (Self-illustrated)

Target level	Primary indicator A	Secondary indicator C
Indicator system for students' evaluation of teaching	Teaching content A_1	Pertinence B_1
		Spirit cultivation B_2
		High order B_3
		Innovativeness B_4
		Challenge B_5
	Teaching ability A_2	Teaching basic skills B_6
		Teaching control B_7
		Teaching research ability B_8
	Teaching method A_3	Instructiveness B_9
		Inquisitiveness B_{10}
		Enlightenment B_{11}
		Interactivity B_{12}
	Teaching effectiveness A_4	Objective achievement B_{13}
		Ability enhancement B_{14}
		Learning effectiveness B_{15}
	Teacher ethics and morals A_5	Teaching attitude B_{16}
		Academic attitude B_{17}
		Ideal and belief B_{18}
		Moral character B_{19}
		Devotion B_{20}
	Information resources A_6	Information resources B_{21}

3.1 Determination of the Judgment Matrix

AHP is a decision-making method that decomposes the relevant elements in decision-making into different levels such as objectives, criteria, and scenarios, and performs qualitative and quantitative analysis on this basis [6]. The 1–9 scale method was used to quantify the judgment results, and the meanings of the 1–9 scale are shown in Table 2. After the preliminary selection of the indicator system for students' evaluation of teaching, the expert scoring method was used. 15 experts in fields such as management studies and pedagogy were invited to conduct quantitative scoring on the indicator system for students' evaluation of teaching, and the AHP judgment matrix was derived.

The judgment matrix of the primary indicators (self-illustrated) is:

$$A = \begin{bmatrix} 1 & 3.875 & 3.375 & 1.229 & 0.916 & 12.8 \\ \frac{1}{3.875} & 1 & 1.708 & 0.393 & 0.95 & 3.8 \\ \frac{1}{3.375} & \frac{1}{1.708} & 1 & 0.76 & 0.393 & 3.4 \\ \frac{1}{1.229} & \frac{1}{0.393} & \frac{1}{0.76} & 1 & 1.123 & 2.875 \\ \frac{1}{0.916} & \frac{1}{0.95} & \frac{1}{0.393} & \frac{1}{1.123} & 1 & 4.75 \\ \frac{1}{12.8} & \frac{1}{3.8} & \frac{1}{3.4} & \frac{1}{2.875} & \frac{1}{4.75} & 1 \end{bmatrix}$$

The judgment matrices of the secondary indicators (self-illustrated) are:

$$B_1 = \begin{bmatrix} 1 & 0.9775 & 2.75 & 3.625 & 4.167 \\ \frac{1}{0.9775} & 1 & 2.375 & 3.625 & 4.3125 \\ \frac{1}{2.75} & \frac{1}{2.375} & 1 & 2 & 3.25 \\ \frac{1}{3.625} & \frac{1}{3.625} & \frac{1}{2} & 1 & 2.3125 \\ \frac{1}{4.167} & \frac{1}{4.3125} & \frac{1}{3.25} & \frac{1}{2.3125} & 1 \end{bmatrix}$$

$$B_2 = \begin{bmatrix} 1 & 3.3125 & 2.566 \\ \frac{1}{3.3125} & 1 & 0.874 \\ \frac{1}{2.566} & \frac{1}{0.874} & 1 \end{bmatrix}$$

Table 2. Indicator Scoring Explanation (Self-illustrated)

Scale	Definition	Explanation
1	Equally important	The two factors are equally important
3	Slightly important	In comparison with the latter, the former is slightly important
5	Obviously important	In comparison with the latter, the former is obviously important
7	Very important	In comparison with the latter, the former is very important
9	Extremely important	In comparison with the latter, the former is extremely important
2, 4, 6, 8	Intermediate value	The importance of the former in comparison with the latter lies between the upper and lower adjacent scales
Reciprocal	Inverse comparison	In comparison with the former, the latter is more important

Table 3. Average Random Consistency Index RI (Self-illustrated)

Order	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59
Order	16	17	18	19	20	21	22	23	24	25	26	27	28
RI	1.594	1.606	1.613	1.621	1.629	1.636	1.640	1.646	1.650	1.656	1.659	1.663	1.667

$$B_3 = \begin{bmatrix} 1 & 2.104 & 1.816 & 3.25 \\ \frac{1}{2.104} & 1 & 0.999 & 2.041 \\ \frac{1}{1.816} & \frac{1}{0.999} & 1 & 3.25 \\ \frac{1}{3.25} & \frac{1}{2.041} & \frac{1}{3.25} & 1 \end{bmatrix}$$

$$B_4 = \begin{bmatrix} 1 & 0.623 & 0.629 \\ \frac{1}{0.623} & 1 & 2.416 \\ \frac{1}{0.629} & \frac{1}{2.416} & 1 \end{bmatrix}$$

$$B_5 = \begin{bmatrix} 1 & 2 & 0.706 & 4.66 & 0.65 \\ \frac{1}{2} & 1 & 0.833 & 1.156 & 7.2 \\ \frac{1}{0.706} & \frac{1}{0.833} & 1 & 2 & 2.525 \\ \frac{1}{4.66} & \frac{1}{1.156} & \frac{1}{2} & 1 & 1.541 \\ \frac{1}{0.65} & \frac{1}{7.2} & \frac{1}{2.525} & \frac{1}{1.541} & 1 \end{bmatrix}$$

3.2   Consistency Test

In order to examine the consistency of the judgment matrix, the software MATLAB was used to calculate the largest eigenvalue λ_{max} of the above judgment matrix. The eigenvector $W = (\omega_1, \omega_2, \ldots, \omega_n)^T$ and the consistency index value CI were obtained after normalization. The judgment value $CR = CI/RI$. When $CR < 0.1$, the degree of consistency of the judgment matrix is considered acceptable. The random consistency index RI, which is a fixed value determined by the order of the judgment matrix, is the mean of the average random consistency index. The value of RI is shown in Table 3. The eigenvector W_i is the weight of each indicator. After calculation, the above judgment matrices all meet the criteria of the consistency test. The evaluation results are as follows.

Primary indicator $W = (0.32\ 0.13\ 0.10\ 0.20\ 0.21\ 0.04)$ $CI = 0.065, CR = 0.052 < 0.1$;

Secondary indicator $W_{Teaching content} = (0.34\ 0.33\ 0.17\ 0.10\ 0.06)$ $CI = 0.023, CR = 0.020 < 0.1$;

$W_{Teaching\ ability} = (0.59\ 0.19\ 0.22)$ $CI = 0.001, CR = 0.002 < 0.1$;

$W_{Teaching\ method} = (0.42\ 0.22\ 0.26\ 0.10)$ $CI = 0.014, CR = 0.016 < 0.1$;

$W_{Teaching\ effectiveness} = (0.23\ 0.49\ 0.28)$ $CI = 0.043, CR = 0.082 < 0.1$;

$W_{Teacher\ ethics\ and\ morals} = (0.18\ 0.17\ 0.29\ 0.20\ 0.16)$ $CI = 0.067, CR = 0.038 < 0.1$.

Table 4. Weights in the Indicator System for Students' Evaluation of Teaching (Self-illustrated)

Primary indicator A	Weight	Secondary indicator B	Weight
Teaching content A_1	0.32	Pertinence B_1	0.34
		Spirit cultivation B_2	0.33
		High order B_3	0.17
		Innovativeness B_4	0.10
		Challenge B_5	0.06
Teaching ability A_2	0.13	Teaching basic skills B_6	0.59
		Teaching control B_7	0.19
		Teaching research ability B_8	0.22
Teaching method A_3	0.10	Instructiveness B_9	0.42
		Inquisitiveness B_{10}	0.22
		Enlightenment B_{11}	0.26
		Interactivity B_{12}	0.10
Teaching effectiveness A_4	0.20	Objective achievement B_{13}	0.23
		Ability enhancement B_{14}	0.49
		Learning effectiveness B_{15}	0.28
Teacher ethics and morals A_5	0.21	Teaching attitude B_{16}	0.18
		Academic attitude B_{17}	0.17
		Ideal and belief B_{18}	0.29
		Moral character B_{19}	0.20
		Devotion B_{20}	0.16
Information resources A_6	0.04	Information resources B_{21}	0.04

4   Conclusions

According to the AHP evaluation results, the weights in the indicator system for students' evaluation of teaching in universities are shown in Table 4. As can be seen from Table 4, teaching content has the greatest weight of the primary indicators, i.e., teaching content is the most important among the primary indicators. Teacher ethics and morals have the second greatest weight. Teaching content and teacher ethics and morals are the two most important aspects of teachers' teaching and teaching quality improvement. Meanwhile, information resources have less impact on the improvement of teaching quality. The pertinence and spirit cultivation of teaching content have the greatest weights among the secondary indicators of teaching content, while the challenge has the least weight and the least importance. Among the secondary indicators of teaching ability, basic teaching skills have the greatest weight of 0.59, which indicates that teachers' basic teaching skills are the basis of their teaching ability, with evident importance. Among the secondary indicators of teaching methods, instructiveness has the greatest weight

while interactivity has the least weight. Among the secondary indicators of teaching effectiveness, ability enhancement has the greatest weight. Teaching in universities is oriented toward improving students' abilities in all aspects, so ability enhancement is the most powerful verification of teaching effectiveness. The weight of each secondary indicator of teacher ethics and morals does not differ much. The ideal and belief have the greatest weight of 0.29, which shows that the premise of putting morality first is to establish the correct ideal and belief.

Students' evaluation of teaching in universities is a complicated task. The preparation and optimization of the indicator system are also complicated. It should consider not only the professional knowledge of pedagogy and educational measurement but also the influence of possible uncertainties in practical application, such as the influence of stakeholders. This paper only uses the AHP method to optimize the indicator system and the weights. In addition, the optimization of the indicator system also requires planning and coordination for the evaluation mechanisms, evaluation platform construction, evaluation institutions, and evaluation subjects.

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