Construction and Application of Fuzzy Evaluation Index System for Classroom Teaching Quality of Applied Undergraduate

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Keywords: AHP Fuzzy Evaluation, Classroom Teaching Quality, Applied Undergraduate.

Abstract. Based on the research and achievements of collegiate classroom teaching quality evaluation at home and abroad, combined with AHP fuzzy evaluation theory, this paper constructed the applied undergraduate classroom teaching evaluation index system by using AHP, and applied it to the comprehensive evaluation of the applied undergraduate classroom teaching quality in Chongqing A college. The research results basically verified the effectiveness and feasibility of the evaluation index system, which has positive reference significance for the continuous improvement of the applied undergraduate classroom teaching quality evaluation of Chongqing A college and the teaching quality evaluation of similar colleges.

1. Introduction

The influencing factors of collegiate classroom teaching quality evaluation are often various and fuzzy, so it is difficult to give an accurate evaluation. Therefore, T.L. Saaty proposed a qualitative and quantitative analytic hierarchy process (AHP)\textsuperscript{[1]} and L.A. Zadeh proposed a fuzzy comprehensive evaluation method based on the fuzzy membership theory\textsuperscript{[2]}, which became a powerful tool to solve classroom teaching evaluation problems.

2. Review of Current Research

The research on classroom teaching quality evaluation at home and abroad mainly focused on the evaluation standards. It is believed that the key to scientifically and effectively identify classroom teaching quality is to design an evaluation index system that can comprehensively reflect the teaching activities. Gu believed that classroom quality standards should be formulated according to the quality concept of popular higher education, multiple-value orientation and the characteristics of applied undergraduate\textsuperscript{[3]}. On the analysis of the evaluation index of "teaching by teaching", Li thought that the evaluation indexes of classroom teaching should emphasize "teaching by learning" and reflect the overall development of students, and have been designed from three perspectives of students, peer teachers and supervision experts respectively\textsuperscript{[4]}. Bacherhicks et al. thought there are three primary indicators of teaching quality: student test-based measures (i.e., value added), classroom observations, and student surveys\textsuperscript{[5]}. Mangiante believed that teacher effectiveness be determined, in significant part, by student growth measures and supplemented with multiple observation-based assessments which helped to link teacher evaluations with teacher effectiveness\textsuperscript{[6]}. Seheffler, an American philosopher of analytical education, believed that three standards should be observed in "teaching activities": intentional judgment standard, rational judgment standard and attitude standard\textsuperscript{[7]}. The
Netherlands applied technology universities mostly adopted classification evaluation standards, highlighting the applicability and career orientation indicators\(^8\).

In addition, there were more researches on the evaluation subjects and contents. The subjects were focused on multiple subjects, single subjects and key subjects, and the contents were focused teaching objectives, teaching contents, teaching methods and teaching effects. Based on the analysis of the traditional summative evaluation of classroom teaching, Xu proposed a classroom teaching evaluation model which highlights the student-centered evaluation, while takes the teacher's self-evaluation and peer review as the reference\(^9\). Through the study of students' adverse selection and moral hazard, Li believed that students' single subject, as a participant in the whole process of classroom teaching, is fully capable of evaluating teachers' teaching quality\(^10\). Abdelhadi and nurunabi believe that students' teaching evaluation, as the main basis for evaluating teaching quality, is conducive to efficient teaching quality and has been successfully applied to engineering students in Saudi Arabia\(^11\). Using AHP and fuzzy evaluation methods, Zhang and Wu determined that the evaluation contents of flipped classroom teaching include pre-class learning materials, classroom teaching activities and classroom teaching effect\(^12\).

The above domestic and foreign research had become a reference for similar research, but most of them focused on the general undergraduate teaching evaluation, which has little significance for the evaluation of applied undergraduate classroom teaching quality.

3. Construction of Fuzzy Evaluation Index System for Classroom Teaching Quality

3.1. Construction Principles

1) Scientificity principle. The construction of evaluation index system should be based on theory and facts, which indicators and data should be set, collected and analyzed scientifically.

2) Feasibility principle. The construction of evaluation index system should be simple and easy to implement.

3) Procedural principle. The purpose of evaluation is to improve and promote teaching, which is step-by-step. so we should pay attention to the procedural indicators while indexes designing.

4) Generality principle. Any subject has the consistency of teaching quality and evaluation concept, which comment index design should highlight the common characteristics of applied undergraduate classroom teaching.

5) Diversity principle. Classroom teaching evaluation is based on both teaching theory and practice feedback, so its indexes construction needs the participation of experts, teachers, students and managers. Multiple subjects participate in the construction of classroom teaching evaluation indexes, which helps to enhance the subject's indicator recognition. The higher the recognition of the indicators, the more positive the participants' attitude, and the more effective the classroom teaching evaluation.

3.2. Index Contents

Some studies had shown that: excellent classroom teaching characteristics are composed of many factors, but the relatively important characteristics are teaching content, teaching attitude, teaching methods, teaching effect, etc. According to the principles of scientificity, feasibility and generality of evaluation index construction, this paper selected the teaching attitude, teaching content, teaching method, teaching organization and teaching effect shared by most applied undergraduate evaluation
as the primary indicators. Combined with the professional characteristics and the practical experience of classroom teaching evaluation in Chongqing A college, the content such as students’ participation and absorption degree were integrated into the secondary indicators. In this way, the draft index system was formed. Then the draft indicators were investigated from the perspective of students, teachers and experts. According to the survey results, the experts who put forward opinions were interviewed to found out the reasons for modification. Finally the indicators were revised to form the evaluation index system of classroom teaching quality. See Table 1. Therefore, the evaluation index system can not only reflect the ideas and attitudes of students and teachers, but also integrate the advanced ideas and teaching experience of experts, which credibility and professionalism were improved.

### 3.3. Index Weights

The weight is a quantity value to compare and weigh the relative importance of various factors in the evaluation, which is used to indicate the proportion of each factor in the whole. Different weights represent different value orientations of the reviewers. The objective accuracy of evaluation results is directly related to the scientific setting of evaluation indexes and weights.

Scientific weight construction methods include analytic hierarchy process, Delphi method, expert ranking method, key feature investigation method, 9-scale method, triangular fuzzy number scaling method, matrix dual method, etc[^13]. This paper adopted the expert ranking method, which is simple to understand and easy to operate. It can eliminate the subjective factors in expert opinions to a certain extent. At the same time, it can make full use of the experts' profound teaching theory and rich teaching experience to increase the credibility of the weight. The specific method is as follows: the primary and secondary indicators in Table 1 were designed into a questionnaire, and seven experts and three student representatives were invited to rank the importance of the indicators at all levels. Finally, the formula \( W_i = 2/n(1+m)-R_i/[mn(1+m)] \) was used for statistics, where \( m \) is the number of indicators, \( n \) is the number of experts, \( R_i \) is the sum of the ranked levels of the \( i^{th} \) indicator by experts, and \( W_i \) is the weight of the \( i^{th} \) indicator[^14]. After the statistical calculation of expert ranked data, the specific weight of each index is shown in Table 1.

<table>
<thead>
<tr>
<th>Primary index</th>
<th>Weight</th>
<th>Secondary index</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching attitude ( u_1 )</td>
<td>0.15</td>
<td>1. Proper appearance and full of spirit ( u_{11} )</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Full preparation, serious teaching and strong sense of responsibility ( u_{12} )</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Rigorous and approachable ( u_{13} )</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. To be a model for others ( u_{14} )</td>
<td>0.2</td>
</tr>
<tr>
<td>Teaching content ( u_2 )</td>
<td>0.3</td>
<td>1. To carry out the syllabus, locate accurately and highlight the key and difficult points ( u_{21} )</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Complete materials, large amount of information, clear levels and appropriate depth ( u_{22} )</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Absorbing the latest achievements of the discipline, enlightening, extensible and innovative ( u_{23} )</td>
<td>0.2</td>
</tr>
</tbody>
</table>

[^13]: Reference for weight construction methods.
[^14]: Reference for calculation method of weight.
4. Integrating theory with practice and paying attention to the cultivation of application ability $u_{24}$ 0.2

1. Advanced teaching concept and unique teaching style $u_{31}$ 0.2
2. Teaching according to the content, stimulating learning interest $u_{32}$ 0.3
3. Stressing the guidance of learning method, cultivating students' self-study ability $u_{33}$ 0.3
4. Selecting reasonable teaching method according to the characteristics of the course and teaching practice $u_{34}$ 0.2

1. Normal organization of teaching, creating a harmonious teaching environment $u_{41}$ 0.2
2. Vivid teaching process, active classroom atmosphere, and good interaction between teacher and students $u_{42}$ 0.25
3. Arousing students' emotion, concentrating their attention $u_{43}$ 0.25
4. Compact teaching section, effective class time $u_{44}$ 0.3

1. High learning attitude and interest in the course $u_{51}$ 0.2
2. High degree of absorption for basic knowledge, theory and skills $u_{52}$ 0.3
3. Improvement of students' ability to analyze and solve problems $u_{53}$ 0.3
4. To achieve the teaching requirements and objectives of this course $u_{54}$ 0.2

### 4. Application of Fuzzy Evaluation System for Classroom Teaching Quality

#### 4.1. Determining the Evaluation Factor Set

According to the evaluation index system in Table 1, there are five primary evaluation indexes for classroom teaching quality, namely $u_1$, $u_2$, $u_3$, $u_4$, $u_5$. So the primary evaluation factor set $U=(u_1, u_2, u_3, u_4, u_5)$ can be constructed. Similarly, each secondary evaluation factor set can be established successively: $U_1=(u_{11}, u_{12}, u_{13}, u_{14})$, $U_2=(u_{21}, u_{22}, u_{23}, u_{24})$, $U_3=(u_{31}, u_{32}, u_{33}, u_{34})$, $U_4=(u_{41}, u_{42}, u_{43}, u_{44})$, $U_5=(u_{51}, u_{52}, u_{53}, u_{54})$.

#### 4.2. Determining the Evaluation Factor Weight Set

Saaty put forward 9-scale method in AHP theory on how to set the weight of primary or secondary evaluation factors objectively and reasonably[15]. The expert ranking method was used to determine the weight of each factor in this paper, see Table 1. The primary evaluation factor weight set was $A=(a_1, a_2, a_3, a_4, a_5)$, while the secondary evaluation factors weight sets were $A_1=(a_{11}, a_{12}, a_{13}, a_{14})$, $A_2=(a_{21}, a_{22}, a_{23}, a_{24})$, $A_3=(a_{31}, a_{32}, a_{33}, a_{34})$, $A_4=(a_{41}, a_{42}, a_{43}, a_{44})$, $A_5=(a_{51}, a_{52}, a_{53}, a_{54})$.

#### 4.3. Determining the Evaluation Variable Set

After determining the evaluation factors set, the evaluation variables set was formed by giving values of a certain meaning to each ultimate evaluation factor. In this paper, the final percentage of each grade (excellent, good, medium and poor) of the secondary evaluation factors in Table 1 was
defined as the evaluation variable value. For example, the evaluation variable set of each secondary index under "teaching attitude" was as follows: \( U_{11}=(u_{111} u_{112} u_{113} u_{114}) \), \( U_{12}=(u_{121} u_{122} u_{123} u_{124}) \), \( U_{13}=(u_{131} u_{132} u_{133} u_{134}) \), \( U_{14}=(u_{141} u_{142} u_{143} u_{144}) \), which were combined into a fuzzy evaluation matrix \( R_{U1} \) for "teaching attitude".

\[
R_{U1} = \begin{pmatrix}
  u_{111} & u_{112} & u_{113} & u_{114} \\
  u_{121} & u_{122} & u_{123} & u_{124} \\
  u_{131} & u_{132} & u_{133} & u_{134} \\
  u_{141} & u_{142} & u_{143} & u_{144}
\end{pmatrix}
\]

Similarly, we can get \( R_{U2} \), \( R_{U3} \), \( R_{U4} \), \( R_{U5} \).

### 4.4. Constructing a Comprehensive Evaluation Model

According to fuzzy theory, the primary factor evaluation variables set is equal to the product of the secondary factors weight set and the matrix formed by the secondary factors evaluation variables set. Similarly, the final evaluation variable set is equal to the product of the primary factor weight set and the matrix composed of the primary factor evaluation variable set. Therefore, the final evaluation variable set is \( R_{st} \).

\[
R_{st} = A \times R_c = A \times \begin{pmatrix}
  A \times R_{U1} \\
  A \times R_{U2} \\
  A \times R_{U3} \\
  A \times R_{U4}
\end{pmatrix}
\]

### 4.5. Case Evaluation

In this paper, by tracking the classroom teaching quality of a teacher in Chongqing A college, the fuzzy evaluation data of 37 students, 7 peer teachers and 4 teaching administrators (including supervisors) were statistically analyzed by classroom listening and student discussion. See Table 2.

1) Students' fuzzy evaluation for teaching quality. According to the evaluation statistics in Table 2, the proportion matrix of 37 students with different grades was calculated.

\[
R_{c1} = \begin{pmatrix}
  0.73 & 0.22 & 0.05 & 0.00 \\
  0.57 & 0.24 & 0.16 & 0.03 \\
  0.46 & 0.43 & 0.11 & 0.00 \\
  0.70 & 0.19 & 0.08 & 0.03
\end{pmatrix},
R_{c2} = \begin{pmatrix}
  0.76 & 0.22 & 0.03 & 0.00 \\
  0.68 & 0.19 & 0.14 & 0.00 \\
  0.35 & 0.35 & 0.16 & 0.14 \\
  0.54 & 0.27 & 0.16 & 0.03
\end{pmatrix},
R_{c3} = \begin{pmatrix}
  0.49 & 0.46 & 0.05 & 0.00 \\
  0.43 & 0.46 & 0.11 & 0.00 \\
  0.41 & 0.41 & 0.16 & 0.03 \\
  0.30 & 0.49 & 0.19 & 0.03
\end{pmatrix},
R_{c4} = \begin{pmatrix}
  0.57 & 0.38 & 0.05 & 0.00 \\
  0.49 & 0.24 & 0.24 & 0.03 \\
  0.27 & 0.46 & 0.24 & 0.03 \\
  0.30 & 0.49 & 0.19 & 0.03
\end{pmatrix},
R_{c5} = \begin{pmatrix}
  0.46 & 0.27 & 0.27 & 0.00 \\
  0.49 & 0.24 & 0.27 & 0.00 \\
  0.27 & 0.49 & 0.22 & 0.03 \\
  0.51 & 0.24 & 0.24 & 0.00
\end{pmatrix}
\]

The primary evaluation weight set \( A=(0.2 \ 0.3 \ 0.15 \ 0.2 \ 0.15) \) and the secondary evaluation weight sets \( A_1=(0.2 \ 0.3 \ 0.3 \ 0.2) \), \( A_2=(0.3 \ 0.3 \ 0.2 \ 0.2) \), \( A_3=(0.2 \ 0.3 \ 0.3 \ 0.2) \), \( A_4=(0.2 \ 0.25 \ 0.25 \ 0.3) \), \( A_5=(0.2 \ 0.3 \ 0.3 \ 0.2) \) in Table 2 were brought into the comprehensive evaluation model in the previous section, and the evaluation conclusion of all students on the teacher’s teaching quality was obtained as follows:
The conclusion shown that among all the students evaluation, excellent accounted for 50%, good accounted for 33%, medium accounted for 15%, and poor accounted for 2%.

Table 2. Statistics of classroom teaching quality evaluation.

<table>
<thead>
<tr>
<th>Primary index</th>
<th>Secondary index</th>
<th>Student evaluation(37)</th>
<th>Peer evaluation(7)</th>
<th>Administrators evaluation(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Excellent</td>
<td>Good</td>
<td>Medium</td>
</tr>
<tr>
<td>U1</td>
<td>U11</td>
<td>27</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>U12</td>
<td>21</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>U13</td>
<td>17</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>U14</td>
<td>26</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>U2</td>
<td>U21</td>
<td>28</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>U22</td>
<td>25</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>U23</td>
<td>13</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>U24</td>
<td>20</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>U3</td>
<td>U31</td>
<td>18</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>U32</td>
<td>16</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>U33</td>
<td>15</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>U34</td>
<td>11</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>U4</td>
<td>U41</td>
<td>21</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>U42</td>
<td>18</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>U43</td>
<td>10</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>U44</td>
<td>11</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>U5</td>
<td>U51</td>
<td>17</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>U52</td>
<td>18</td>
<td>9</td>
<td>10</td>
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<td></td>
<td>U53</td>
<td>10</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>U54</td>
<td>19</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

$R_{stj} = A \times R_s = (0.2 \times 0.3 \times 0.15 \times 0.2 \times 0.15) \times \begin{bmatrix} 0.59 & 0.28 & 0.11 & 0.01 \\ 0.61 & 0.25 & 0.11 & 0.03 \\ 0.41 & 0.45 & 0.13 & 0.01 \\ 0.39 & 0.40 & 0.19 & 0.02 \\ 0.42 & 0.32 & 0.25 & 0.01 \end{bmatrix} = (0.50 \times 0.33 \times 0.15 \times 0.02)$
2) Peers and administrators’ fuzzy evaluation for teaching quality. According to the peers and administrators’ evaluation statistics in Table 2, the comprehensive evaluation for teaching quality was obtained by the same method

\[ \text{Rst}_2 = (0.2 \ 0.3 \ 0.15 \ 0.2 \ 0.15) \times \begin{pmatrix} 0.51 & 0.30 & 0.19 & 0.00 \\ 0.54 & 0.24 & 0.19 & 0.03 \\ 0.36 & 0.43 & 0.21 & 0.00 \\ 0.38 & 0.36 & 0.21 & 0.04 \\ 0.39 & 0.33 & 0.29 & 0.00 \end{pmatrix} = (0.45 \ 0.31 \ 0.22 \ 0.02) \]

\[ \text{Rst}_3 = (0.2 \ 0.3 \ 0.15 \ 0.2 \ 0.15) \times \begin{pmatrix} 0.60 & 0.33 & 0.08 & 0.00 \\ 0.60 & 0.25 & 0.10 & 0.05 \\ 0.45 & 0.35 & 0.20 & 0.00 \\ 0.41 & 0.39 & 0.20 & 0.00 \\ 0.43 & 0.33 & 0.25 & 0.00 \end{pmatrix} = (0.50 \ 0.32 \ 0.16 \ 0.02) \]

3) Comprehensive fuzzy evaluation for teaching quality. The comprehensive evaluation matrix composed of the above conclusions from three evaluation subjects on teaching quality was as follows.

\[ \text{Rst} = \begin{pmatrix} \text{Rst}_1 \\ \text{Rst}_2 \\ \text{Rst}_3 \end{pmatrix} = \begin{pmatrix} 0.50 & 0.33 & 0.15 & 0.02 \\ 0.45 & 0.31 & 0.22 & 0.02 \\ 0.50 & 0.32 & 0.16 & 0.02 \end{pmatrix} \]

In the evaluation application, the weight of each evaluation subject is different. The students, peers and administrators’ evaluation weight in Chongqing A college was \( \text{Ar} = (0.45 \ 0.15 \ 0.4) \). Therefore, the final evaluation conclusion of all participants on the teacher’s teaching quality was as follows.

\[ D = \text{Ar} \times \text{Rst} = (0.45 \ 0.15 \ 0.4) \times \begin{pmatrix} 0.50 & 0.33 & 0.15 & 0.02 \\ 0.45 & 0.31 & 0.22 & 0.02 \\ 0.50 & 0.32 & 0.16 & 0.02 \end{pmatrix} = (0.49 \ 0.33 \ 0.16 \ 0.02) \]

The conclusion shown that among all the participants, 49% were excellent, 33% were good, 16% were medium and 2% were poor.

5. Discussion and Prospect

1) In this paper, AHP and Delphi method are adopted to construct the evaluation index system, and the expert ranking method is used to determine the index weight. The evaluation index system is relatively scientific and reasonable, but the sample size of the case is relatively low. The conclusion credibility and the deviation in some indicators from the actual situation need to be corrected by large-scale sample experiments.

2) Based on fuzzy statistics and operation, the evaluation conclusion are relatively objective, but the conclusion can only show “a certain degree” advantages and disadvantages on teaching quality, which is not convenient for direct evaluation application. Therefore, the matrix \( E = (95 \ 80 \ 65 \ 50) \) can be set to represent the four grade scores, then the evaluation result will be converted into percentage value \( F = D \times E' = 84.35 \).
3) The application results of the fuzzy evaluation index system in this paper are in line with the actual teachers’ evaluation in Chongqing A college, which can basically verify the effectiveness and feasibility of the evaluation index, index weight distribution and fuzzy evaluation method.

Fuzzy evaluation based on large-scale statistics and operation can enhance the effectiveness of its indicators and the credibility of the results. Therefore, the follow-up research can focus on the informatization of fuzzy evaluation to improve its efficiency.

Acknowledgments

Fund project. 2020 Scientific research project of Chongqing Institute of Technology "Research and Application of Small Software Project Management Model Based on CMM" (No.: 2020xxzx01)

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