# Capability Evaluation of Postgraduate Tutors Based on the Combination of Fuzzy Comprehensive Evaluation and Analytic Hierarchy Process

Demei Sun[1,a], Yang Chen[1,b*], HongBin Wang[1,c]

[1] *School of Economics and Management, Harbin Engineering University, Harbin, Heilongjiang, China*
[a]*sundemei2005@163.com,* [*b]*matthewchenyang@live.com,* [c]*wanghongbin1964@hrbeu.edu.cn*
*Corresponding Author: Yang Chen*

**Abstract**
To understand the Capability of graduate tutors, after analysing the literature on the capability of tutors, analytic hierarchy process is used to construct a Capability evaluation system which contain 33 three-level indicators to evaluate the tutor's capability level. Then this study takes five academic master tutors as examples to implement the established evaluation system. It's found that the overall level of tutor's capability needs to be improved, and the age factor is an important reference to judging tutor's capability.

***Keywords:*** *higher education, tutor Capability, fuzzy comprehensive evaluation, analytic hierarchy process, evaluation system*

## 1.INTRODUCTION

Postgraduate education is an important way to cultivate high-level talents for society. The capability of graduate tutors is directly related to the quality of graduate's training. In the current teaching management system of colleges, there are many inherent evaluation ways for the graduate tutors. However, such methods are generally developed from tutor evaluation, consist of student evaluation, school evaluation (supervision) and other evaluations. The main observation basis is the completion of the teaching process. Such methods are not scientific enough for graduate education. The method's observation angle does not include the performance of tutor's ability, tutor's sense of responsibility, tutor's ethics, etc. So, it cannot be used as a suitable method of evaluating the Capability of tutors. Therefore, we need to construct a suitable evaluation model for the Capability of graduate tutors.

To overcome the shortcomings in previous research, this study selected and screened several relevant indicators based on the relevant studies and established a multi-level tutor Capability evaluation system by using the Analytic Hierarchy Process (AHP) method. Through the evaluation method established by this study, it's possible to make further research on the Capability of college tutors and make the progress of graduate training and tutor's management. In the future, more explorations can be made in educational evaluation research by using the combination of fuzzy comprehensive evaluation method and analytic hierarchy process.

## 2.MATERIALS AND METHODS

### *2.1. Opinion collation*

In order to provide reference for the evaluation model established by this study, it's necessary to sort out the previous research's results of the graduate tutor and Capability. In this study, the CiteSpace software was used to analyse 500 literatures with a high number of citations in the themes of "tutor evaluation" and "tutor capability" in the web of science database with a time zone of 1 year.

The study found that keywords of related study include evaluation literacy, tutor evaluation, analytic hierarchy process, teaching evaluation, developmental evaluation and performance evaluation, which shows that previous studies focus on the tutor's teaching, peers, and performance. The analysis also found that the Analytic Hierarchy Process is the main method used to establish evaluation content.

The focus on the capability of graduate tutors began in the early part of this century. There have been three major research booms in tutor evaluation and Capability


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evaluation. The first time was the focus on tutors' teaching performance in 2004-2007, and the second time was in 2011-2014 to focus on the evaluation of tutor's performance in Western countries. Mainly, the third time in 2018, focus on the evaluation of the capability of the tutors. The change of research's focus reflects that the evaluation of the capability of graduate tutors is developed from the evaluation of tutor performance.

**Table 1:** Summary of factors affecting the capability of graduate tutor

| | Influencing factors | Opinion summary and document source |
|---|---|---|
| Factors Influencing Capability of Graduate Tutors | Professional knowledge | Knowledge level[7], professional skills [2], research capabilities[6], Professional development ability [15] |
| | Resources | Research and exchange opportunities [10], Resources of the research team[14] |
| | Professionalism | The volunteer spirit of the tutor[8], Frequency of communication between students and tutors [1], Guidance to students on graduation thesis[4], Teaching ability [3] |
| | Character | Interpersonal skills [5], Care for students [11], Fear of student[12], Tutor-student relationship[9] |
| | Morality | Morality and personality traits[13] |

The different influencing factors of the capability of graduate tutors were put forward by different scholars, as shown in Table 1. From the literature review, we can see that the capability of a tutor is not a single dimension, but a comprehensive reflection of a series of behaviours.

## 2.2. Evaluation System

The Analytic Hierarchy Process, abbreviated as AHP, is a method of decomposing complex multi-objective problem into multiple aspects. This study will establish an evaluation system for the capability of graduate tutors based on the AHP method.

On the basis of summarizing the previous study, the first-level indicators which including the "tutor ability", "tutor-student communication", "student performance" and "multiple evaluation" are established. On this basis, the second-level indicators and the third-level indicators are established. The complete index system is shown in Table 2.

**Table 2:** Capability Evaluation System and Reliability and Validity Test of University Graduate Tutors

| First level indicator | Second level indicators | Reliability | Third level indicators | Reliability after deletion | Validity | Censored validity |
|---|---|---|---|---|---|---|
| A1 The ability of tutors | B1 Academic and research capabilities | 0.720 | C1 Number of high-level papers published | 0.636 | 0.916 | 0.910 |
| | | | C2 Number of patents | 0.625 | 0.958 | 0.954 |
| | | | C3 Number of books and teaching materials published | 0.636 | 0.733 | 0.736 |
| | | | C4 Research team size | 0.625 | 0.958 | 0.954 |
| | | | C5 Scientific research funds managed in the past five years | 0.599 | 0.830 | 0.840 |
| | | | C6 Number of academic misconducts | 0.917 | 0.113 | |
| | B2 Ability to work | 0.875 | C7 Cumulative teaching hours | 0.840 | 0.932 | 0.926 |
| | | | C8 Administrative job level | 0.841 | 0.968 | 0.961 |
| | | | C9 Number of part-time jobs | 0.850 | 0.884 | 0.879 |
| | | | C10 Working hours off campus | 0.943 | 0.414 | |
| | | | C11 Number of graduated masters | 0.844 | 0.777 | 0.799 |
| | | | C12 Number of graduated Ph.Ds. | 0.845 | 0.936 | 0.939 |
| | | | C13 Work aggressiveness evaluation | 0.846 | 0.794 | 0.809 |
| A2 Tutor-student | B3 Number of communications | 0.813 | C14 Average number of communications with students | 0.785 | 0.480 | 0.489 |
| | | | C15 Average number of group meetings | 0.756 | 0.910 | 0.869 |

| | | | | | | |
|---|---|---|---|---|---|---|
| communication | | | C16 Annual working hours on campus | 0.767 | 0.889 | 0.918 |
| | | | C17 Average number of students' graduation thesis guidance | 0.779 | 0.612 | 0.565 |
| | | | C18 Student-tutor-student relationship evaluation | 0.784 | 0.714 | 0.799 |
| | | | C19 Number of communications between students and other tutors | 0.786 | 0.736 | 0.722 |
| | | | C20 Average number of students communicating with each other | 0.868 | 0.269 | |
| | B4 Resources | 0.811 | C21 Number of students participating in scientific research projects | 0.895 | 0.651 | 0.546 |
| | | | C22 Average number of students exchange opportunities | 0.649 | 0.899 | 0.877 |
| | | | C23 Average research funding of students | 0.640 | 0.881 | 0.905 |
| A3 Student performance | B5 Academic and academic performance | 0.790 | C24 Number of Papers Published | 0.717 | 0.808 | 0.880 |
| | | | C25 Number of academic conferences attended | 0.756 | 0.534 | 0.605 |
| | | | C26 Number of patents | 0.732 | 0.857 | 0.839 |
| | | | C27 Student grade point average | 0.762 | 0.691 | 0.628 |
| | | | C28 Abnormal graduation rate of students | 0.788 | 0.607 | 0.641 |
| | B6 Employment performance | 0.903 | C29 Employment ratio of Fortune 500 companies | 0.936 | 0.895 | 0.907 |
| | | | C30 Employment ratio of government agencies | 0.809 | 0.914 | 0.910 |
| | | | C31 Proportion of postgraduate | 0.847 | 0.876 | 0.853 |
| A4 Multiple evaluation | B7 Student Evaluation | 0.808 | C32 Student satisfaction evaluation of tutor | 0.964 | 0.562 | 0.535 |
| | | | C33 Evaluation of students' recognition of tutor's work | 0.628 | 0.922 | 0.944 |
| | | | C34 Evaluation of students' recognition of getting along with tutors | 0.686 | 0.935 | 0.956 |
| | B8 Other comments | 0.384 | C35 Colleagues' evaluation of tutor's work recognition | 0.343 | 0.726 | 0.718 |
| | | | C36 Evaluation of the school's recognition of the tutor's work | 0.103 | 0.682 | 0.824 |
| | | | C37 Parents' appraisal of tutor's work recognition | 0.595 | 0.244 | |

In this study, several scholars and education experts who participated in the work of graduate were asked to rate the importance of the third level indicators from 1 to 5, which served as the basis for the scientific nature of the research index. In order to ensure the consistency of all items, we designed a variety of sentence patterns to describe the same item, to avoid the investigator's understanding deviation to the greatest extent. Then, SPSS22.0 software was used to perform factor analysis, and common factors were extracted from the 37 preliminarily established indicators. Through factor analysis, we can clarify the correspondence between the third-level indicators and clarify the scientific nature of each indicator.

According to the characteristics of the evaluation system, the reliability of the eight secondary indexes was tested respectively. Cronbach's Alpha values are shown in the "reliability" column of Table 2. They are: 0.72, 0.875, 0.813, 0.811, 0.79, 0.903, 0.808, 0.384. It can be seen that the reliability of some indicators is low, indicating that evaluation need to be modified. Factor validity analysis found that, as shown in the "validity" column of Table 2, the factor loading under the maximum variance method was the lowest 0.244, which was less than 0.4, indicating that there was a problem with the validity of the evaluation system.

The third level indicators were deleted one by one, and the reliability changes were observed, as shown in the column of "deleted reliability" in Table 2. It's observed

that after deleting the C6, C10, C20, C21, C29, C32, and C37, the reliability of the second-level indicators has improved. Therefore, after discussion by experts, the four items C6, C10, C20, and C37 were deleted to ensure the reliability and validity of the system. Validity analysis on the remaining 33 third level indicators is shown in the column "validity after deletion" in Table 2.

### *2.3. Give weight by fuzzy comprehensive evaluat ion method*

In order to complete the empowerment process of this study, the opinions of experts will be consulted. Since each expert has different views, which makes the judgment on the importance of each factor will also be different. Therefore, experts are required to score 1-5 points on the importance of the evaluation index, and we can obtain a final score through the calculation of the fuzzy comprehensive evaluation method. The specific process is:

(1) Determine the evaluation set:

$$V=\{v_1,v_2,\ldots,v_n\} \tag{1}$$

The elements $v_n$ is the degree of importance of evaluation. Determine the set of factors through expert importance evaluation:

$$U_i=\{u_1,u_2,\ldots,u_n\}^T \tag{2}$$

The elements $u_n$ is the score of the third level indicators to be evaluated on the importance of each evaluation, that is, the proportion of experts who judge the importance of the third level indicators to be evaluated as belonging to the evaluation set.

(2) Determine the importance set:

$$P=\{p_1,p_2,\ldots,p_n\}. \tag{3}$$

The elements $p_n$ is the importance of the third level indicators to be evaluated, which is the product of the evaluation set and the factor set:

$$p_i=V*U_i \tag{4}$$

A pairwise comparison of $p_i$ can obtain the matrix $A_{n*n}$ in the hierarchical analysis method, and the third level indicators weight vector $W_i$ to be evaluated is calculated by the hierarchical analysis method.

(3) Carry out single factor evaluation and calculate the evaluation matrix $R$ according to the expert's importance judgment table :

$$r_{ij}=d_{ij}/(d_{i1}+d_{i2}+\ldots+d_{ij}) \tag{5}$$

In this function, $d_{ij}$ is the number of experts who judge the importance of the third level indicators to be evaluated and belong to the evaluation set $V_i$.

(4) By calculating the importance $B_i$ of the secondary index, the corresponding secondary index and the weight of the primary index can be obtained by repeating the above operation.

$$B_i=W_i*R*V^T \tag{6}$$

After the above research steps are determined, the relevant calculations will be carried out in SPSS 22.0 software. Relevant data is obtained on the questionnaire survey platform, and the data is entered into the software through manual statistics. The calculation results of all weights are shown in Table 3.

**Table 3:** Capability Evaluation System of University Graduate Tutors

| First level indicator | Weights | Secondary level indicators | Weights | Third level indicators | Weights |
|---|---|---|---|---|---|
| A1 The ability of tutors | 0.28 | B1 Academic and research capabilities | 0.59 | C1 Number of high-level papers published | 0.20 |
| | | | | C2 Number of patents | 0.21 |
| | | | | C3 Number of books and teaching materials published | 0.19 |
| | | | | C4 Research team size | 0.21 |
| | | | | C5 Scientific research funds managed in the past five years | 0.19 |
| | | B2 Ability to work | 0.41 | C6 Cumulative teaching hours | 0.17 |
| | | | | C7 Administrative job level | 0.17 |
| | | | | C8 Number of part-time jobs | 0.17 |
| | | | | C9 Number of graduated masters | 0.16 |
| | | | | C10 Number of graduated Ph.Ds. | 0.17 |
| | | | | C11 Work aggressiveness evaluation | 0.16 |
| A2 Tutor-student communication | 0.25 | B3 Number of communications | 0.46 | C12 Average number of communications with students | 0.17 |
| | | | | C13 Average number of group meetings | 0.17 |
| | | | | C14 Annual working hours on campus | 0.17 |
| | | | | C15 Average number of students' graduation thesis guidance | 0.16 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | C16 Student-tutor-student relationship evaluation | 0.17 |
| | | | | C17 Number of communications between students and other tutors | 0.16 |
| | | B4 Resources | 0.54 | C18 Number of students participating in scientific research projects | 0.33 |
| | | | | C19 Average number of students participating in exchange opportunities | 0.34 |
| | | | | C20 Average research funding of students | 0.33 |
| A3 Student performance | 0.26 | B5 Academic and academic performance | 0.59 | C21 Number of Papers Published | 0.20 |
| | | | | C22 Number of academic conferences attended | 0.20 |
| | | | | C23 Number of patents | 0.20 |
| | | | | C24 Student grade point average | 0.20 |
| | | | | C25 Abnormal graduation rate of students | 0.20 |
| | | B6 Employment performance | 0.41 | C26 Employment ratio of Fortune 500 companies | 0.32 |
| | | | | C27 Employment ratio of government agencies | 0.33 |
| | | | | C28 Proportion of postgraduate | 0.35 |
| A4 Multiple evaluation | 0.21 | B7 Student Evaluation | 0.59 | C29 Student satisfaction evaluation of tutor | 0.32 |
| | | | | C30 Evaluation of students' recognition of tutor's work | 0.34 |
| | | | | C31 Evaluation of students' recognition of getting along with tutors | 0.34 |
| | | B8 Other comments | 0.41 | C32 Colleagues' evaluation of tutor's work recognition | 0.51 |
| | | | | C33 Evaluation of the school's recognition of the tutor's work | 0.49 |

## 3.RESULTS & DISCUSSION

This study selects five graduate tutors from Harbin Engineering University as the objects to be evaluated. All data are collected through tutor interviews, student interviews, and other surveys. The five tutors are numbered as "Tutor 1", "Tutor 2", "Tutor 3", "Tutor 4", and "Tutor 5" in descending order of age. A five-level evaluation set of indicators was determined based on expert recommendations, and scores of 1-5 correspond to the five-level evaluations of "extremely low", "low", "medium", "high", and "very high" respectively. The total score is converted into a full score of 100 points. After selecting the triangular membership function to calculate the evaluation set of all levels of indicators, the final scores are shown in Table 4.

**Table 4**: Evaluation scores of five graduate tutors

| Tutor | 1 | 2 | 3 | 4 | 5 | average |
|---|---|---|---|---|---|---|
| Total | 40.21 | 36.95 | 53.49 | 54.13 | 52 | 47.356 |
| A1 | 18.22 | 20.43 | 45.62 | 54.05 | 47.15 | 37.094 |
| A2 | 39.48 | 38.72 | 67.64 | 64.85 | 57.58 | 53.654 |
| A3 | 44.87 | 34.55 | 43.99 | 39.94 | 41.59 | 40.988 |
| A4 | 64.64 | 59.84 | 58.9 | 59.07 | 64.72 | 61.434 |
| B1 | 15.48 | 18.77 | 52.26 | 54.86 | 48.38 | 37.950 |
| B2 | 22.17 | 22.8 | 36.06 | 52.88 | 45.38 | 35.858 |
| B3 | 55.12 | 50.28 | 79.15 | 54.59 | 54.85 | 58.798 |
| B4 | 26.15 | 28.88 | 57.84 | 73.6 | 59.9 | 49.274 |
| B5 | 39.8 | 24 | 28.8 | 27.15 | 27.9 | 29.530 |
| B6 | 52.18 | 49.73 | 65.85 | 58.34 | 61.29 | 57.478 |
| B7 | 69.26 | 58.18 | 60.42 | 58.2 | 70.69 | 63.350 |
| B8 | 57.99 | 62.23 | 56.73 | 60.32 | 56.15 | 58.684 |

From the evaluation results, the scores of the five evaluated tutors are roughly divided into two levels, tutor 1 and tutor 2 are at the same level, tutor 3, tutor 4 and tutor 5 are at the same level. This result shows that the evaluation system has a good performance of distinction between different levels.

The tutors scored the lowest on the academic performance at B5, which shows that as an academic master tutor, the academic requirements of students should be improved. In terms of student evaluation, all five tutors have achieved relatively high results, which shows that the students are generally satisfied with the work of the tutor.

The five tutors showed significant age differences in their scores, with older graduate tutors getting higher

scores. In terms of specific scores, young tutors mainly lag behind in academic ability and work ability, and the provision of academic resources, which shows that working time is an important reference for measuring the capability of graduate tutors. Although there are disadvantages in academic achievement and resource provision, the performance of young tutors is not inferior in terms of student performance and multiple evaluations, which shows that student training results are not only related to the academic strength of the tutors.

Judging from the evaluation of the five tutors, it's found that there is still much room for improvement in the capability of graduate tutors to adapt to the development of higher education. Relevant training and communication mechanisms should be established to improve the capability of graduate tutors. The training should focus on postgraduates to improve students' academic ability and improve tutor-student communication. Although young tutors have disadvantages in academic achievement, they still achieve good results in the academic development of students. Young tutors have more experience in academic communication due to their age advantages, so colleges and universities can establish communication work that enhances the capability of tutors.

## 4.CONCLUSIONS

This study sorted out the main factors affecting the capability of graduate tutors in the current research. The study found that the personal ability of the tutor, the communication between the tutor and the student, the performance of the student, and the multiple evaluation can reflect the Capability of the tutor best. Then, using the analytic hierarchy process, this study established a three-level indicators system to evaluate the capability of graduate tutors. Next, this study evaluates five graduate tutors of different ages in Harbin Engineering University. It's found that the evaluation system has a good performance in the distinction between different levels. The requirements of graduate tutors for students are not strict and the students are generally satisfied with the work of the graduate tutor. Young tutors lag behind mainly in academic ability and work ability, as well as in the provision of academic resources. The scores are not much different in student performance and multiple evaluations. In general, the capability of the graduate tutor still needs to be improved.

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