Journal of Education and Learning (EduLearn)
Vol. 19, No. 3, August 2025, pp. 1250~1261
ISSN: 2089-9823 DOI: 10.11591/edulearn.v19i3.22711

Exploring teacher competency indicators in colleges and universities in the context of the digital age

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Article Info

Article history:

Received Jul 8, 2024
Revised Sep 9, 2024
Accepted Sep 19, 2024

Keywords:

Competence
Digital information technology
Higher education teachers
Indicator constructs
Indicator system

ABSTRACT

In the context of the digital age, the marketisation, internationalization, and knowledge-based characteristics of Chinese higher education are being challenged by global competition. Institutions of higher education in this competitive environment must adopt digital-era human resource management concepts, strategies, and techniques to gain a competitive advantage in development. This study constructs a comprehensive and scientific competency index system for Chinese university teachers. The competency indicators of college teachers are mainly formed through the Fuzzy Delphi method, and the competency indicator system of college teachers is formed through the fuzzy hierarchical analysis method. The research object is 20 college teachers. The results of the study indicate that the index system includes self-structure, knowledge structure, and competence structure, with 3 level 1 indicators, 6 level 2 indicators, and 37 level 3 indicators, which can provide decision-making information for recruitment, promotion, transfer, and dismissal in the human resource management of schools. This study can significantly promote the professional growth of higher education teachers, enhance the quality of higher education, and respond to the core issues attending educational reform and development in the digital age.

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1. INTRODUCTION

Currently, the characteristics related to the era of digital information technology have propelled China's higher education to a globalised competitive environment; for universities in a fiercely competitive environment to gain a competitive advantage in the development process, they should utilize modern human resource management methods and techniques [1]. Human resource management functions based on the competency theory are a crucial basis for the effective implementation of various functions in the process of human resource management and technical prerequisites. The application of the competency theory to build a competency evaluation index of college teachers in the digital information age is a crucial component affecting the construction of the college faculty; thus, the government can enhance the quality of higher education and solve the current critical reform-related issues affecting higher education in the digital information age [2]–[4]. Higher education is tasked with the cultivation of high-quality talents; higher education faculty competence directly determines the quality of the incoming higher education faculty, and by strengthening the evaluation of the competence affecting the higher education faculty, the government can enhance the quality of higher education [5], [6]. Therefore, the establishment of a scientific and reasonable

index system for teacher competence in colleges and universities, and the application of correct methods and scientific means to evaluate teachers are crucial to both school and teacher development.

Higher education teaching was once regarded as a non-essential, stable, and well-benefited profession; however, studies have revealed that most higher education teachers work 8-10 hours a day, and approximately 90% of them exceed the required working hours by more than one hour a day [7]. High-intensity, overloaded work may not yield the desired results; contrastingly, such crucial overdrafts are likely to lead to burnout and job alienation, affect their job satisfaction, lead to turnover, and even affect their physical and mental health [8]. From a functional perspective, college teachers perform a variety of functions; for the role of college teachers, the current social expectations have (for an extensive period) been not only limited to roles such as talent trainer, knowledge creator, social service provider, and cultural inheritance and innovation, but also expanded and enhanced to digital citizenship cultivator, wisdom educator, innovation and entrepreneurial talent cultivator, creator of original achievements, incubator of knowledge achievements, and international exchange and cooperation. The ever-expanding responsibilities and soaring demands, coupled with fragmented administrative duties, often leave university teachers overwhelmed and disoriented [9], [10]. In such a working condition, the competent performance of college teachers is a cause for concernmerits research attention. Especially in recent years, with the new challenges of 'Internet+Education', innovation and entrepreneurship education, and other teachers' work tasks, the competency evaluation indexes of college teachers in smart teaching, flipped classroom teaching, small private online course (SPOC) blended teaching, innovation, and entrepreneurship education remain undeveloped [11]. This study utilizes the competence of teachers in colleges and universities in China as an entry point, constructs a set of indicators of teachers' competence in colleges and universities for the current digital information era using the Fuzzy Delphi method [12], [13], and utilizes the fuzzy hierarchical analysis method to determine the weights of the indicators; subsequently, the study forms the evaluation system, characterized by indicators exhibiting the competence of teachers in colleges and universities, which provides first-line information and constructive proposals for the construction of China's college and university teaching force and provides references for the development, evaluation, and recruitment of teachers in colleges and universities [14], [15]. Thus, the study offers first-line information and constructive proposals for the construction of China's university teaching force and provides a reference for the development and evaluation of university teachers.

2. LITERATURE REVIEW

Introducing the competency theory and the characteristics of the digital information age into the construction of college teacher competency evaluation indexes, and analyzing college teacher competency evaluation indexes from the essential attributes of competency, it is not difficult to find that the continuous improvement and refinement of college teacher competency evaluation indexes is an intrinsic necessity, thus rationalizing their existence. First, for ontology, the connotation, structure, and mode of college teacher competency are related to its professional role expectations, i.e., the practitioner's ontology of competency should be up to date and continuously cater to the profession's social role expectations [16]. Second, for the value theory, the research value of college teachers' competency evaluation indexes should be reflected in the field of practice, and the impact of college teachers' competency evaluation on job performance, job satisfaction, and job well-being highlights the existential value of college teachers' competency evaluation [17]–[19]; finally, regarding the practice theory, the college teachers' competency evaluation indexes should be measurable and perfectible [20].

Lin and Huang [21] proposed that the rapid development of information technology in recent years has prompted countries not only to attach great importance to the cultivation of teachers' information-based education and teaching ability in the new era but also to issue relevant documents for guiding and supporting the training of new teachers. Subsequently, Li and Hu [22] study proposed that teachers, who can crucially guarantee the teaching level of colleges and universities, are an essential resource for their healthy development; the study, which commenced from the perspective of modernizing higher education, comprehensively explored the corresponding core qualities of physical education teachers in colleges and universities and applied techniques such as qualitative analysis, the Delphi method, and the hierarchical analysis method, thereby constructing a comprehensive index system that included ideological character, educational competence, teaching ability, and scientific research expertise. A comprehensive index system with four first-level indicators was constructed. However, some colleges and universities still lack data support in the process of evaluating teachers' teaching ability, which leads to an unscientific and unreasonable evaluation process and makes it difficult to objectively and fairly reflect teachers' real teaching ability. Liu *et al.* [23] noted that the main problem of the current teaching evaluation index system is the lack of a teaching document evaluation index system. The selection of classroom teaching evaluation indexes in colleges and universities is biased in favour of 'teaching by teaching', and fails to account for the respective

advantages of different evaluation subjects; the classroom teaching evaluation index system should reflect the 'teaching by learning' approach, and construct a classroom teaching with students' evaluation as the main component, with peer evaluation and experts' evaluation as the supplement. Leileia and Sukpascharoenb [24] utilized three private colleges and universities in China as the research object; consistent with the literature, the scholar established the evaluation index system using the hierarchical analysis method, determined the index weights, adopted the fuzzy comprehensive evaluation method, constructed a fuzzy comprehensive evaluation model of adopting the college academic style, and evaluated the level of academic style construction in private colleges and universities. Jiang and Yu [25] established a digital competency model for teachers through the Delphi method and the grounded theory, which is centred around three aspects: development, pedagogy, and ethics. Li [26] constructed a teacher ethics evaluation index system for college teachers from the evaluation system's hierarchical structure diagram, and the results indicated that the evaluation scores of teachers in 10 colleges and universities in the areas of dedication to work, teaching, rigour in teaching, and serving as a role model were 3.975, 3.946, 4.075, and 4.078, respectively. Compared with the other two teachers, the comprehensive evaluation scores of teacher Q in school 1 increased by 7.13% and 12%, respectively. It can be observed that the evaluation index system of teachers' morality and ethics in colleges and universities can effectively evaluate the quality of teachers' morality and ethics.

Holst *et al.* [27] noted that a complete set of education indicators should not only focus on current policies, but also be a system that contains a wide range of education topics and is capable of continuous development. Shao [28] also noted that the construction of indicators should follow ten principles: representativeness and prominence; quantifiable and easy to obtain; reliable statistical measurements; usable for comparing environmental conditions across time and space; high sensitivity to temporal and spatial environmental change; ability to predict future trends in environmental change; clear purpose of application, with policy relevance; adequate scientific basis; easy to use; and clear and easy to understand.

Furthermore, education indicators must be integrated with education assessment. The purpose of assessment is not to prove, but to improve; only assessed indicators can be understood in terms of their utility and applicability. Herein, the construction of teacher competency indicators in higher education accounts for the current need to enhance the quality of teacher training in China, thereby constructing a suitable indicator system that can be utilized as a reference for future teacher training and evaluation.

Li *et al.* [29] noted that the complete procedure of constructing an education indicator system is as follows: selecting the indicator construction method: the construction of education indicators should exhaustively consider the professional, time, and financial conditions, and select an appropriate method for appropriately constructing the indicators; considering the people who construct the indicators: inviting the relevant parties to express their opinions and reflecting the opinions of the relevant parties; constructing the indicator system: first, performing data collection and analysis, and constructing indicators according to the chosen method; interpreting indicators: after completing the construction of the indicator, analyse and interpret the significance of the indicators; and evaluate and correct the indicator system: a satisfactory education indicator system must go through the process of successive cycles of researching, testing, correcting, re-testing, and re-correcting.

Cao *et al.* [30] noted that the main methods for constructing an educational indicator include literature discussion, expert judgment, focus group interviews, and the Delphi method. When educational indicators have been widely analysed and there is a large amount of literature to be collected, the literature discussion method can be utilized to construct the indicators. This study aims to construct indicators of college teachers' competence, which entails more externally related research; therefore, the literature constructs preliminary indicators, and the specific procedures are as follows. Literature collection: this study first collects the connotation of the theory of teacher development in colleges and universities, the significance of competence, the connotation of evaluation indicators of college and university teachers in the relevant research, and collects externally related literature as much as possible, to provide thus providing a wide range of references for this study; listing and determining the categories of indicators: this study combines the relevant indicators in the literature exploration, combined with the relevant policy needs for the preliminary construction of the level indicators; and indicator classification: the indicators mentioned by Chinese and foreign researchers with a high frequency are categorized into level indicators.

Competency indicator system construction provides a common tool and method for integrating human resource functions and services and offers a novel approach and perspective for constructing a new management system for teachers [31]. Introducing competency theory and method into the management of teachers and establishing a set of competency reference systems for teachers in colleges and universities in the digital information era is conducive to enhancing the scientificity of teacher selection and recruitment, enhancing the pertinence of training, strengthening the accuracy of performance appraisal, and prompting the teachers to grow faster into the excellent talents required by colleges and universities.

3. RESEARCH METHODOLOGY

3.1. Research process

Firstly, based on the research purpose and existing problems of the paper title, and through the collection and organization of relevant literature, the meaning of competence, the meaning of university teachers, the connotation and theory of university teacher competence were explored, providing theoretical basis for the research. On the basis of the literature, the competence index of Chinese university teachers was initially constructed, and expert validity verification was conducted. Secondly, based on the preliminary construction of competency indicators for Chinese university teachers, a Delphi method expert questionnaire was developed. Finally, after completing the expert validity evaluation, a Fuzzy Delphi method was used to design an expert questionnaire, collect and analyze the opinions and suggestions of the expert group on the indicators, establish the competence indicators for university teachers through statistical analysis, and determine the weights of the indicators using the fuzzy analytic hierarchy process based on the indicator construction.

3.2. Fuzzy Delphi method

According to the "college teachers' competency index," which was validated by experts, this study formulated the "fuzzy delphi expert questionnaire on college teachers' competency," including three levels, namely self-structure, knowledge structure, and competency structure, six dimensions, and 37 itemized indexes. The questionnaire includes 3 levels, namely self-structure, knowledge structure, and ability structure, 6 dimensions, and 37 detailed indicators. The expert questionnaires was distributed on August 5, 2023, and all the questionnaires were collected on September 10, 2023; the questionnaire recovery rate attained 100%. The expert questionnaire was compiled as per Likert's five-point scale (very important, important, general, unimportant, and very unimportant), and each item was marked with a scale of 1-5, where "5" denotes very important, "4" denotes important, "3" denotes average, "2" denotes unimportant, and "1" denotes "very unimportant." The questionnaire was filled out in a semi-structured manner, and the experts expressed their personal opinions on the suitability of the questionnaire indicators; if they thought that some indicators needed to be modified or deleted, they could propose modifications in the open-ended comments column.

3.3. Fuzzy hierarchy analysis

The execution procedure of fuzzy hierarchical analysis is almost the same as that of traditional hierarchical analysis; however, fuzzy hierarchical analysis requires setting fuzzy semantics, defuzzification, and regularization. Because the weights must be assigned with consideration of the respondents' expertise and consistency, the respondents of the second phase of this study, "expert questionnaire on relative weights of competency indicators of college teachers," are still the experts of the Fuzzy Delphi method in the first phase. The researcher distributed 20 questionnaires on September 9, 2023 and collected 20 questionnaires on October 9, with a 100% recovery rate. To determine the weights of the indicators for the competence of university teachers, first, based on the "indicators of the competence of university teachers" amended in the first stage with reference to the experts' opinions, the fuzzy positive and negative matrices were established by comparing two-by-two and establishing the positive and negative matrices of each expert to obtain the triangular fuzzy number of the experts' opinions, and the fuzzy positive and negative matrices were subsequently established. Herein, approximation method is applied to compare the weights, and the final weights of each index are formed using a hierarchical cascade method.

3.4. Participant characteristics

According to the research purpose and problems of the dissertation topic, and based on the collection and organization of related literature, the meaning of competence, the meaning of college teachers, and the connotation and theory of college teacher competence are explored to provide a theoretical basis for the study, and based on the literature, the index of Chinese college teacher competence is initially constructed. According to the preliminary construction of China's college teacher competency indicators, the expert validity recognition questionnaire of china's college teacher competency indicators was designed, and 10 experts and scholars in the higher education domain were invited to conduct an expert content validity review, to examine the content of the preliminary constructive college teacher competency indicators in the form of a questionnaire, and to propose revised opinions and proposal to confirm the validity of the research indicators' content. According to the experts' research fields and specialties, 20 experts were selected for the Fuzzy Delphi method expert group, including 10 experts and scholars, 5 educational managers, and 5 frontline teachers. The Delphi method expert questionnaire was prepared according to the preliminary construction of the competency indicators of Chinese college teachers. Using the Fuzzy Delphi method, the researchers integrate the expert group's opinions; by integrating the experts' open-ended opinions, the levels and directions of the indicators and the appropriateness of the specific contents of the indicators are corrected and supplemented; finally, the indicators of the competence of teachers in Chinese colleges and universities are formed. Design the questionnaire for pairwise comparison of Chinese university teachers' competence

indicators, ask the experts of the preceding Fuzzy Delphi method to fill in the answers, and determine the weights of each indicator by utilizing the fuzzy hierarchical analysis method.

4. RESULT

4.1. Quantitative statistical results of the expert questionnaire of the first stage of the Fuzzy Delphi method

Herein, the total value of the triangular fuzzy number is utilized to measure the consensus degree of the fuzzy Delphi expert group on each indicator, and the final result is based on the threshold value for the screening of the indicator; if the total value of the triangular fuzzy number of a certain indicator is higher than the threshold value, the indicator will be "adopted"; if the total value of the triangular fuzzy number is lower than the threshold value, the indicator is "discarded". Herein, the total value of the triangular fuzzy number denoted as "important" in the assessment scale is 0.7, which is the threshold value; if the total value of the triangular fuzzy number of an indicator is ≥0.7, the indicator is accepted, whereas if the total value of the triangular fuzzy number of an indicator is <0.7, the indicator is discarded.There are three-dimensional indicators, namely self-structure, knowledge structure, and ability structure, of which "self-structure" has the highest total value of a triangular fuzzy number (0.833), and "knowledge structure" has the lowest total value of a triangular fuzzy number (0.733). The total value of the triangular fuzzy number for all dimensions is higher than the threshold value (0.7); therefore, all three dimensions are accepted, as illustrated in Table 1.

The first level indicators of the competence index system for Chinese university teachers can be regarded as the fundamental core of their competence. The second and third level indicators provide more specific and in-depth explanations of these basic abilities, providing a broader and more accurate perspective for evaluation.In the dimensional indicators section, among the 6 dimensions, the dimension with the highest total value for the triangular fuzzy number is "personality traits" (0.753), whereas the dimension with the lowest total value of a triangular fuzzy number is "service traits" (0.73). Because the total value of a triangular fuzzy number of all dimensional indicators is higher than 0.7, all 6-dimensional indicators are adopted as shown in Table 2.

In the breakdown indicator section, the total value of the triangular fuzzy number of the 37 breakdown indicators is higher than the threshold value (0.7). Therefore, all 37 breakdown indicators are adopted as shown in Table 3 (see in appendix). By synthesizing the quantitative information provided by the preceding Fuzzy Delphi method experts, having identified the key competency factors required of tertiary teachers in carrying out the duties of their positions and distilled from these the core qualities and competencies expected of high-performing tertiary teachers, the index of college teacher competency was finally constructed as a structure exhibiting three levels, six dimensions, and thirty-seven detailed indicators.

Table 1. Tabulating the results of the selection of indicators of the competence dimension of teachers in higher education

No.	Dimension	Total value of fuzzy triangular numbers	Sort	Results
A	Self-structure	0.833	1	Choose
B	Knowledge structure	0.733	3	Choose
C	Competence structure	0.753	2	Choose

Table 2. Tabulating the results of the selection of indicators of the dimension of competence of teachers in higher education

No	Dimension (math.)	Total value of fuzzy triangular numbers	Sort	Results
A-1	Personality traits	0.753	1	Choose
A-2	Student-oriented traits	0.743	2	Choose
B-1	Cognitive characteristics	0.733	1	Choose
B-2	Service characteristics	0.730	2	Choose
C-1	Teaching skills characteristics	0.740	1	Choose
C-2	Scientific research characteristics	0.737	2	Choose

4.2. Results of relative weights of indicators of college teachers' competence level

Competency indicators of college teachers are divided into three levels: self-structure, knowledge structure, and ability structure. After the questionnaire analysis of the weights of the indicators of each level, the weight value of the self-structure level is 0.383, the weight value of the knowledge structure level is 0.283, and the weight value of the ability structure level is 0.333; the weight value of the indicators is 0.333. Knowledge structure. After the consistency check of the questionnaire was completed by the experts, the

consistency index C.I.=0.077<0.1, which indicates that the consistency of the experts' opinions is within an acceptable range as shown in Table 4.

There are two-dimensional indicators, namely personality traits and student-oriented traits, under the self-structure level, and after analyzing the results of the questionnaire from experts, the consistency index C.I.=0.025<0.1, which is consistent with the consistency test. The weight of the personality traits dimension is 0.550, whereas the weight of the student-oriented dimension is 0.450, and the personality traits dimension is more crucial as shown in Table 5. Therefore, possessing noble personality traits is a key factor in determining whether university teachers can fulfill their teaching responsibilities.

The itemized indicators under the personality traits dimension at the self-structural level include A-1-1 positive attitude of hope and confidence in life goals, meaning of life, and career choice. A-1-2 ability to cope with the pressure of the daily working environment. A-1-3 understanding and respecting other people's concepts and behaviors. A-1-4 consciousness of making efforts to achieve the goals. A-1-5 consciousness of doing one's job well and dedicating oneself to the cause of education. A-1-6 consciousness in getting along with people and devoting oneself to the cause of education. A-1-7 can objectively recognize their own strengths and weaknesses, and objectively evaluate the successes, failures, successes, and mistakes in their work. A-1-8 is able to provide assistance and answers to reasonable requests and questions from others without complaining. A-1-9 taking and telling the truth, not covering up and facts as their code, totaling 9 indicators. After analyzing the results of the expert questionnaire, the consistency indicator C.I.=0.070<0.1, which is consistent with the consistency test. The indicator "A-1-2 ability to correctly cope with the pressure of daily work environment" has the highest weight and is the most important as shown in Table 6.

The itemized indicators under the dimension of student-oriented characteristics at the self-structure level contain eight itemized indicators. A-2-1 knowledge of relevant laws, regulations, policies, and safety protection regarding the growth, development, and protection of students. A-2-2 respecting, guiding, and loving the physical and mental health of students. A-2-3 considering the interests of students when making judgments and performing them. A-2-4 effectively listening to the opinions and respecting students' suggestions. A-2-5 the ability to communicate with students with appropriate methods. A-2-6 love for educational work. A-2-7 the teaching process is enthusiastic. A-2-8 the teaching style is passionate and contagious. After analyzing the results of the expert questionnaire, the consistency index C.I.=0.068<0.1, which is consistent with the consistency check. "A-2-1 Knowledge of relevant laws, regulations, policies and safety protection knowledge about students' growth and development and protection" accounted for the highest weight value, which is the most crucial among the indicators under the dimension of student-oriented characteristics as shown in Table 7.

Table 4. Distribution of weights of indicators at the level of competence of higher education teachers

Indicators of competency dimensions of higher education teachers	Weight (%)	Sort
A. Self-structure	0.383	1
B. Knowledge structure	0.283	3
C. Competence structure	0.333	2
C.I.=0.077		

Table 5. Table of relative weights assigned to the indicators of the two dimensions under the self-structural dimension

Self-structural dimensions	Weight (%)	Sort
A-1 Personality traits	0.550	1
A-2 Student-oriented traits	0.450	2
C.I.=0.025		

Table 6. Distributing weights of line-item indicators under personality trait dimensions under the self-structure level

Personality trait dimensions	Weight (%)	Sort
A-1-1	0.119	2
A-1-2	0.122	1
A-1-3	0.100	9
A-1-4	0.114	4
A-1-5	0.117	3
A-1-6	0.103	8
A-1-7	0.111	5
A-1-8	0.106	7
A-1-9	0.108	6
C.I.=0.070		

Table 7. Distribution of weights of line-item indicators under the dimension of student-oriented characteristics at the self-structure level

Student-oriented characteristics dimension	Weight (%)	Sort
A-2-1	0.138	1
A-2-2	0.134	2
A-2-3	0.123	5
A-2-4	0.120	6
A-2-5	0.130	3
A-2-6	0.127	4
A-2-7	0.116	7
A-2-8	0.113	8
C.I.=0.068		

There are two-dimensional indicators under the knowledge structure level: cognitive characteristics and service characteristics. After analyzing the results of the expert questionnaire, the consistency indicator C.I.=0.050<0.1, which is consistent with the consistency test. Regarding the importance of the indicators, the weight of the cognitive characteristics indicator is 0.600, and the weight occupied by the service characteristics indicator is 0.400, which indicates that the experts as a whole propose that cognition is more crucial than service as shown in Table 8.

The dimension of cognitive characteristics under the knowledge structure level contains five line-item indicators. B-1-1 having solid professional knowledge and relevant work experience. B-1-2 being able to master the subject specialization in a systematic manner, and caring for and understanding the subject's advanced level of development. B-1-3 the ability to integrate new knowledge into the already existing knowledge. B-1-4 being able to systematically and proficiently express the subject's mastered knowledge and to propose original insights, hypotheses, and theories based on the rich accumulation of knowledge. B-1-5 in addition to the discipline's specialized knowledge, the theoretical knowledge related to education and teaching is also mastered. The analysis results of the expert questionnaire indicated that the consistency indicator C.I.=0.086<0.1, which is consistent with the consistency check. The item "B-1-4 can systematically and skillfully express the acquired knowledge of the discipline and can propose original opinions, hypotheses, and theories based on rich knowledge accumulation" has the highest weight value (0.235), which is the most crucial as shown in Table 9.

The dimension of service characteristics under the knowledge structure level contains four itemized indicators, which are as follows: B-2-1 extend the scope of work outside the university and use their wisdom and knowledge to provide services to the society; B-2-2 actively participate in a variety of academic activities to disseminate and exchange new concepts and theories; B-2-3 actively contribute to the development of the university by taking ownership of the school and actively making suggestions and contributing to the development of the university; and B-2-4 actively participate in the disciplinary development of their secondary units. "B-2-1 extends the scope of work outside the university and utilizes their wisdom and knowledge to provide services to the society" has the highest weight value (0.292), which is the most crucial. After analyzing the results of the expert questionnaire, the consistency indicator C.I.=0.077<0.1, which is consistent with the consistency test as shown in Table 10.

Table 8. Table of relative weights assigned to the indicators of the two dimensions under the knowledge structure dimension

Knowledge structure level	Weight (%)	Sort
B-1 Cognitive characteristics	0.600	1
B-2 service characteristics	0.400	2
C.I.=0.050		

Table 9. Table of weights assigned to line-item indicators under the cognitive traits dimension under the knowledge structure level

Cognitive trait dimensions	Weight (%)	Sort
B-1-1	0.195	3
B-1-2	0.220	2
B-1-3	0.180	4
B-1-4	0.235	1
B-1-5	0.170	5
C.I.=0.086		

Table 10. Table of weights assigned to line-item indicators under the service characteristic dimension under the knowledge structure dimension

Service characteristics dimension	Weight (%)	Sort
B-2-1	0.292	1
B-2-2	0.208	4
B-2-3	0.267	2
B-2-4	0.233	3
C.I.=0.077		

There are two-dimensional indicators, namely teaching skill characteristics and scientific research characteristics, under the level of "competence structure." After analyzing the results of the questionnaire from experts, the consistency indicator C.I.=0.025<0.1, which is consistent with the consistency test. The weight value of the dimension of teaching skills characteristics is 0.550, and the weight value of the dimension of

scientific research characteristics is 0.450. It can be observed that the experts as a whole think that the teaching skills characteristics are more crucial than the scientific research characteristics as shown in Table 11.

The detailed indicators under the dimension of teaching skills characteristics under the competence structure level include the following: C-1-1 the ability to speak fluent Putonghua and express their meanings accurately; C-1-2 the ability to answer students' questions and solve their problems about the teaching content at any time; C-1-3 the ability to skillfully use the multimedia, simulation equipment, and other modernized teaching means during the teaching process; C-1-4 the ability to enthusiastically participate in the policies related to the reform of teaching and learning, active supportive attitude towards the policies related to teaching reform; and C-1-5 the ability to transform excellent teaching theories, teaching experience, and teaching skills into teaching achievements, totaling five indicators. After analyzing the results of the expert questionnaire, the consistency indicator C.I.=0.089<0.1, which is consistent with the consistency check. "C-1-5 ability to transform excellent teaching theory, teaching experience, and teaching skills into teaching results" has the highest weight value and is the most crucial indicator as shown in Table 12.

The detailed indicators under the dimension of scientific research characteristics at the competence structure level include the following: C-2-1 conscious transformation of scientific research results and the ability to transform them into products with academic, social, and economic values; C-2-2 the ability to achieve the expected goals in the process of engaging in scientific research, and the ability to control scientific research projects in general; C-2-3 the ability to propose novel concepts, and the ability to identify research directions according to the frontier of the discipline; and C-2-4 the ability to apply theory to practice in the process of scientific research; C-2-5 quantity and quality of high-level papers published; and C-2-6 cultivation of the next generation of successors for the cause of scientific research. After analyzing the results of the expert questionnaire, it reveals that the consistency indicator C.I.=0.094<0.1, which is consistent with the consistency check. The item "C-2-1 consciously transforms its scientific research results and can transform them into products with academic, social, and economic values" has the highest weight value and is the most crucial as shown in Table 13.

Table 11. Distribution of relative weights of indicators for the two dimensions under the competency structure level

Competency structure levels	Weight (%)	Sort
C-1 teaching skills characteristics	0.550	1
C-2 scientific research characteristics	0.450	2
C.I.=0.025		

Table 12. Distribution of weights of line-item indicators under the dimension of teaching skill characteristics under the competency structure level

Characteristics of teaching skills	Weight (%)	Sort
C-1-1	0.185	4
C-1-2	0.170	5
C-1-3	0.220	2
C-1-4	0.195	3
C-1-5	0.230	1
C.I.=0.089		

Table 13. Distribution of weights of line-item indicators under the dimension of scientific research characteristics under the competence structure dimension

Scientific research characteristics	Weight (%)	Sort
C-2-1	0.197	1
C-2-2	0.140	6
C-2-3	0.187	2
C-2-4	0.150	5
C-2-5	0.157	4
C-2-6	0.170	3
C.I.=0.094		

5. DISCUSSION

For the analysis of the weights of the first-level indicators of teacher competence in colleges and universities, the research results indicate that the weight value of self-structure is the highest at 0.383, which reveals the importance of self-structure, and this finding further emphasizes the urgent concern of colleges and universities about the difficulty of measuring and obtaining the teachers' hidden traits [32]. Therefore,

colleges and universities must dedicate more attention to the self-structural indicators of college teacher competence in the future teacher evaluation process, focusing on strengthening the assessment and development of teachers' personal qualities. Meanwhile, the weight of knowledge structure is lower than that of competence structure, and this result is exceedingly significant for many colleges and universities that take academic qualifications as a crucial indicator of teacher evaluation and recruitment.

The results indicate that the weight of personality traits under the self-structure level is 0.550, and the weight of student-oriented traits is 0.450, which indicates that the weight of personality traits under the self-structure level is more crucial than the weight of student-oriented traits. Blatný *et al.* [33] noted that the main work of teachers in colleges and universities is to directly face the students and to engage in teaching and impart knowledge, and that colleges and universities are a highly open learning place where students can develop freely, which determines that teachers in higher education are both the transmitters of knowledge and the guides of students. Unlike primary and secondary schools, colleges and universities cultivate students with a great deal of openness and tolerance, and students can fully develop their personalities and interests and decide the direction of their future life development in college [34]. Therefore, as teachers who are directly facing students, in addition to teaching professional knowledge, they should also help students discover their interests and areas of development, and guide the spirit of innovation to promote the free development of students. Wang [35] notes that colleges and universities want to cultivate not only students with theoretical knowledge, but also well-rounded college students with the ability to practice in the society; to achieve this purpose, teachers should first have high practical ability, fully recognize the importance of practice, and provide opportunities for cultivating students' practical spirit and ability. Colleges and universities are characterized as follows: anyone can have equal and free exchanges and debates here. A teacher in colleges and universities should not only be a good teacher, but also a helpful friend to the students, learning from each other and developing together with the students. College teachers have unique professional characteristics, whereas college students are the main body of higher education; only an individual with a noble personality is qualified to become a college teacher.

Under the knowledge structure level, the weight of cognitive characteristics is 0.6, and the weight of service characteristics is 0.4, which indicates that under the level of knowledge structure, cognitive characteristics are more crucial than service characteristics; furthermore, college teachers are required to teach and impart knowledge in this specialty, which requires teachers to achieve a high level of theory and practice related to the courses they teach and a considerable degree of understanding of the development trend of the discipline and cutting-edge theories. Zhou *et al.* [36] noted that the work of teachers in colleges and universities requires a high level of knowledge, which is manifested in the certification of academic qualifications, titles, and other qualifications for the practice of the profession. Teachers in colleges and universities should have quite a high level of relevant professional theory and practice, and in addition to a high level of professional knowledge, they should master some theoretical knowledge of education, which provides the necessary tools to master the students' psychology and improve teaching work to provide the necessary support. This observation indicates that college teachers generally propose that the specialized knowledge they have is the basis for competent teaching positions, and without sufficient knowledge reserves, they cannot talk about spreading knowledge to society and contributing to the school.

The results of the study indicate that under the competence structure level, the weight of teaching skills characteristics is 0.550, and the weight of scientific research characteristics is 0.450, which indicates that the primary job of college teachers is still teaching and educating people, followed by engaging in teaching and research; moreover, it is generally accepted that only by engaging in research on teaching skills first can we make the practical better connected to the theoretical, and that the teaching skills are more revealing to the teachers' competence. Tyurina *et al.* [37] noted that teaching skills act as a mediator between the theory of educational science and the effectiveness of teaching practice; teachers with an insufficient level of teaching skills (regardless of whether the mastery of the theory of educational science is rich or not or professional knowledge or not) cannot be effective in the implementation of education and teaching work. Teaching skills, as a key element of teachers' comprehensive quality of teaching, is the main limiting factor for teachers to realize the value of their knowledge and expertise in education science.

6. CONCLUSION

The competency evaluation indexes of college teachers herein include three primary indicators of self-structure, ability structure, and knowledge structure; six secondary indicators of personality traits, student-oriented traits, cognitive traits, service traits, teaching skills traits, and scientific research traits; and thirty-seven tertiary indicators. Using fuzzy hierarchical analysis to calculate the weights of the three first-level indicators, six second-level indicators, and thirty-seven third-level indicators, the calculation results indicate that the weights of the first-level, second-level, and third-level indicators constructed in this period

passed the consistency test. The college teacher competency indicator system not only responds to the demand for professional talents in higher education, but also provides digital information for human resource management decisions such as recruitment, promotion, transfer, and dismissal; identifies the needs for training and developing college teachers; provides feedback for supervising the improvement of teachers' performance; and serves as the basis for organisational incentives and allocations. The first-level indicators in China's university teacher competency index system are most crucial, whereas the second-level and third-level indicators are a more specific and in-depth elaboration of these basic competencies, providing a broader and more precise informational perspective for evaluation. Therefore, colleges and universities can utilize these indicators as benchmarks to break the limitations of traditional selection, recruitment, training, and other evaluation methods, and promote the scientific management and development of the teaching force. This study expects that Chinese higher education institutions can use these criteria as a reference to provide a new perspective for teacher evaluation, so that it is not only limited to the surface performance, but also pays more attention to the intrinsic and essential characteristics of the teachers hidden under the surface, so as to truly promote the future growth of the teachers, break through the limitations of the traditional assessment methods of selection, recruitment, training, and further promote scientific teacher team management and growth.

APPENDIX

Table 3. The results of selecting indicators for the breakdown of competence of teachers in higher education

No.	Total value of fuzzy triangular numbers	Sort	Results
A-1-1	0.753	2	Choose
A-1-2	0.760	1	Choose
A-1-3	0.727	9	Choose
A-1-4	0.743	4	Choose
A-1-5	0.747	3	Choose
A-1-6	0.733	7	Choose
A-1-7	0.740	5	Choose
A-1-8	0.730	8	Choose
A-1-9	0.737	6	Choose
A-2-1	0.757	1	Choose
A-2-2	0.750	2	Choose
A-2-3	0.740	5	Choose
A-2-4	0.737	6	Choose
A-2-5	0.747	3	Choose
A-2-6	0.743	4	Choose
A-2-7	0.733	7	Choose
A-2-8	0.730	8	Choose
B-1-1	0.737	3	Choose
B-1-2	0.743	2	Choose
B-1-3	0.730	4	Choose
B-1-4	0.747	1	Choose
B-1-5	0.727	5	Choose
B-2-1	0.743	1	Choose
B-2-2	0.730	4	Choose
B-2-3	0.737	2	Choose
B-2-4	0.733	3	Choose
C-1-1	0.753	1	Choose
C-1-2	0.743	2	Choose
C-1-3	0.733	4	Choose
C-1-4	0.730	5	Choose
C-1-5	0.737	3	Choose
C-2-1	0.753	1	Choose
C-2-2	0.730	6	Choose
C-2-3	0.747	2	Choose
C-2-4	0.733	5	Choose
C-2-5	0.740	4	Choose
C-2-6	0.743	3	Choose

ACKNOWLEDGEMENTS

The authors have no conflicts of interest to declare that are relevant to the content of this article. We thank our colleagues from Dhurakij Pundit University who provided insight and expertise that greatly assisted the research.

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