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Preparation of a Competence Scale for Applied University Teachers in Anhui Province, China

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Abstract: *As research into the concepts and models of teacher's competence among applied university teachers continues to deepen, there is a pressing need to update existing measurement scales. This study identifies five core dimensions of teacher's competence specific to applied university teachers and develops a new scale comprising 28 items. Data collected from 381 applied university teachers in Anhui Province, China, confirm the reliability and validity of this scale, demonstrating its practical utility for measuring teacher competence. The findings indicate that the type of university (government or private) significantly influences teachers' competence performance, highlighting the close relationship between competence development and organizational support. Additionally, this study employs k-means clustering to classify these teachers into four groups, each representing a different level of competence. These findings offer valuable insights for designing customized teacher training programs and development strategies that align with the specific competence characteristics of applied university teachers.*

Keywords: *applied university teachers; teacher's competence; measurement scale; k-means clustering*

Key Insights

1. This paper focuses on the development and application of a competency measurement scale for teachers in applied universities in Anhui Province, China.
2. Applied universities teachers' competence can be measured in five dimensions in China. According to the measured data, the overall level of teacher competency in applied universities in Anhui Province is good and can be classified into four categories. Meanwhile the organizational characteristics of universities have an impact on teacher competence.

1 INTRODUCTION

Applied universities are institutions that aim to cultivate high-quality applied talents. According to Pan's (2010) definition, these institutions differ from research universities and vocational colleges in China. Over the past decade, applied universities in China have rapidly developed in response to policies promoting the reform and classification of higher education. Furthermore, the Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 (China State Council, 2021) underscores the significance of high-quality development in applied universities for achieving the modernization of higher education in China. However, many applied universities in China still face challenges during their transformation processes, particularly due to a lack of teachers competent in cultivating high-quality applied talents (Li, 2023; Mo et al., 2023; Lan, 2024; Lin, 2024). This situation is also prevalent in applied universities in Anhui Province.

Efforts to establish a high-quality faculty of applied teachers that aligns with the strategic objectives of institutional development are essential to achieve the transformation and development goals of universities. Researchers and policymakers assert that enhancing teachers' competencies can lead to improved student achievement and the effective cultivation of application-oriented talents (Diao et al., 2022; Que, 2022; Anhui Provincial Department of Education, 2020). Teachers at applied universities engage in continuous and dynamic interactions with their students. They are responsible for providing comprehensive information and knowledge, facilitating the acquisition and enhancement of skills, and developing competencies that enable students to effectively analyze and solve practical problems. Additionally, teachers foster strong professional practice capabilities, encourage innovation and creativity, adapt to societal needs, and instill lifelong learning habits. This demanding role necessitates professional competencies and ongoing professional development. This process is referred to as the professionalization of teachers (Mingucci, 2002).

In recent years, competency-based teacher evaluation has gained significant traction in China (Ding et al., 2015; Wu, 2020; Xu and Guo, 2022). When considering the overall development of universities, it is crucial to focus on clearly defining competencies and, more importantly, systematically developing the competencies of university faculty (Hartley et al., 2011). Past measures of teacher competency have been made just to cover the usual universities and have strong shortcomings when used in application universities. Aydin et al. (2024) observe that currently there are very few competent and valid scales to assess the digital competences of teachers and even the developed existing scales do not fully reflect the competencies needed in practice in university context. Such older scales strongly focus on scholarly research along with theories and poorly cover applied skills and practice, industry connections, and application teaching abilities which characterize the distinguishing characteristics of applied universities.

Measurement gap reflects the necessity of specific assessment tools that will reveal the unique professional demands of applied university teachers. Nevertheless, there remains a lack of understanding regarding fundamental questions related to this issue: (1) Competence models designed for university teachers in traditional settings may not adequately capture the unique characteristics of applied undergraduate universities (Lin et al., 2020). Therefore, it is essential to clearly define the concept of competence for applied university teachers and determine effective methods for its assessment. (2) While it is widely acknowledged that university teachers' competencies should evolve to meet the demands of the digital age, existing definitions, models, and frameworks often fall short in fully integrating digital competence into the overall competency framework of applied university teachers. (3) Although several studies have suggested ways to enhance the competence of teachers in applied universities in China, few provide sufficient evidence to demonstrate the quality and reliability of the measurement instruments used.

Therefore, this study aims to develop a comprehensive competence model specifically tailored to applied university teachers and to create and empirically validate a corresponding scale. This model and scale are intended to accurately reflect the unique core competencies required of teachers in applied universities.

2 LITERATURE REVIEW

Competence is typically defined as the integrated combination of knowledge, skills, abilities, and traits necessary for successful execution of tasks within a specific occupation or field by McClelland (1973). University teachers' competency is a community composed of teachers' essential knowledge, professional skills and personal values to fulfill their responsibilities (Hadiyan et al.， 2022), which is associated with good performance of teachers (Chawang, 2020). Possessing a performance dimension, competencies are

observable and demonstrable, so they are also measurable (Nessipbayeva, 2012). In different industries, competence manifests differently and closely aligns with the roles and job requirements. Therefore, assessing competence does not adhere to uniform standards but rather requires the use of model-based evaluations (Zhou, 2024).

2.1. Measurement of Teachers' Competency in Higher Education

University teacher's competence (in terms of professional competence) encompasses a combination of knowledge, skills, and personal characteristics (such as attitude, motivation, and values), reflects job requirements, and is associated with job performance (Tigelaar et al., 2004; Blašková, 2014; Sugianto, et al., 2023). Numerous authors deal with the definition of knowledge, skills, and personal characteristics of university teachers, e.g. Boyer (1990); Mishra and Koehler (2006); Kunter, M. et al. (2013). Based on the previous views and thoughts, many researchers focus on the core professional competencies of university teachers related to their job tasks.

2.1.1 Personal Characteristics Competency

Personal characteristics competency refers to certain constellations of desirable stable characteristics, that is, "good teachers", or those who are successful in their work with a special aptitude or a talent (Kunter, M. et. al., 2013). According to McClelland's (1973) iceberg model of competency, it is underwater. The evolution of teachers' personalities runs parallel to the development of all other dimensions of teacher professionalism (Latipah, E., et al., 2020). Bardach et al. (2022) reviewed various studies and meta-analyses, finding the ability to perceive and manage emotions in oneself and others, which can contribute to better teaching outcomes and reduce stress levels. Beyer, L. et al. (2022) utilized large-scale vision models to validate A good teacher is patient and consistent. Mamites et al. (2022) employed the neutrosophic Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to identify the significance of individual and psychological characteristics on most factors affecting teaching quality. In China, the professional ethics of university teachers is regarded as the most important dimension of competence. Sun and Li (2023) conducted a quantitative analysis of 36 central-level policy texts in China (2012-2022) related to university teacher team construction, revealing a focus on enhancing professional ethics among university teachers.

2.1.2 Teaching Competency

Teaching competency of university teachers encompasses the traits that enable them to effectively achieve their instructional objectives. Teaching competency distinguishes teachers from other professions and plays a pivotal role in the success of the learning process and outcomes for students (Rahman, 2014). Moreover, it is essential for the sustainable development of universities and serves as a key guarantee of high teaching quality (He and Zhao, 2018). Teaching competency of university teachers includes knowledge of pedagogical content, pedagogical innovation, transformation of classroom practices, and improved student outcomes by offering academicians opportunities to explore, reflect on teaching, and develop feedback-driven instructional methods (Turner and Drake, 2016; Shen,2024). With the continuous integration of digital technology in higher education, Technological Pedagogical Content Knowledge (TPACK) serves as a theoretical framework for comprehending the knowledge that teachers require for successful integration of technology in their instruction (Bostancioglu and Handley, 2018). Digital teaching competency enables university teachers to incorporate technological elements into their lessons, thereby expanding their teaching choices and facilitating the learning process for their students, beyond basic digital skills (Esteve-Mon et al., 2020). In the "Teacher Digital Literacy" standards established in China (Ministry of Education, 2022), three indicators are directly related to teaching: digital teaching design, digital teaching implementation, and digital teaching evaluation.

2.1.3 Research Competency

In universities, educators are expected not only to fulfill teaching duties but also to actively engage in academic research within their specialized fields. Research competency serves as a critical distinguishing factor between university teachers and those in primary and secondary education (Li and Peng, 2022). Research competence in applied university contexts should consider forming a direct connection with the practice of education, although they are based on profound theoretical formulation (Ciraso-Cal et al., 2022). Teachers in applied universities make use of their research skills and apply them to the practice of teaching to directly involve in the teaching routine the latest trend in the industry, evidence-based approaches, and solution-problem approaches, making the learning experience authentic and applicable to the real world and bridging the gap between theory and practice. The quantity of publications is widely utilized as a quantitative indicator to evaluate the research output of university teachers. Those who do not enhance their research writing skills tend to produce few publications, thereby affecting the reliability of their work (Agricola et al., 2018). Song (2021), integrating dynamic capability theory, defined research competence as the ability of university teachers to integrate resources, absorb knowledge, and produce creative outcomes, categorized into three dimensions—networking competency, absorptive competency, and innovative competency. Ciraso-Cal et al. (2022) stress that the research competence has to be one of the foundations of university learning where the critical, reflective, and self-controlled thinking that education workers need to demonstrate should be further developed, especially in the spheres of applied learning where the educational process is directly informed by research findings that should also encourage its practical advancement. Mombekova (2024) investigates three components of research competence: the motivational personal component, theoretical cognitive component, and the structural design component. Digital technologies affect the development of research competency (Beisenbayeva et al., 2023; Chen, 2023).

2.1.4 Communication and Cooperation Competency

Communication and Cooperation competency is the basis for carrying out teaching and research activities. Communicative competency among academics, essential for fulfilling communicative tasks during intellectual interactions in the educational process, represents a fundamental component of professional competence within academic staff. It significantly influences the quality of education and the professional self-actualization of faculty members in higher education institutions (Bulvinska, 2017). Zhan et al. (2023) employed the Critical Behavioral Event Interview (CBEI) method alongside questionnaires, integrating the MAP theory model and competency framework, to develop a competency model for teachers at private undergraduate universities. The communication competency category encompasses five indicators: teacher-student communication ability, organizational coordination ability, student-centered orientation, environmental adaptability, and guidance and monitoring. In the digital age, The International Society for Technology in Education (ISTE) standards for teachers are categorized into seven roles or profiles that educators must develop throughout their professional careers. One of these is the Collaborator role, which involves working with colleagues and students to enhance their teaching practice, sharing and exploring ideas and resources, and using ICT to solve problems (ISTE, 2018). Liu et al. (2021) argue that university teachers need to collaborate in unity to engage in knowledge creation. Results improve when scientists and local communities work together, and research has indicated that there is an improvement in terms of diversity, equity, and inclusion of translational science (Nanda et al., 2023). This can be done with the help of clear communication tools, which, in this case, are the Teach Back process allowing both groups to ensure the conversations are understandable, iterative, comprehensive, and transparent. This approach demonstrates that educative community coherence on the team can be enhanced significantly by constructing handy, plausible, and extensively disseminated

tooling, best practices and coverage to a considerable degree. To build high-quality higher education, policymakers encourage international communication and cooperation among teachers in China (Ministry of Education, 2015).

2.2 Specific Competency Requirements for Applied University Teachers

There are different perspectives on the measurement of teachers' competency in applied universities. Practical rather than academic competency more important for teachers in applied colleges and universities, in China (Que, 2022). In Germany, professors at the University of Applied Science must have a doctorate and at least five years of work experience in a relevant field other than university work (Ute Vanini, 2013), these were the recruitment requirements of the German University of Applied Science. In China, the establishment of Dual-Teacher (Ministry of Education, 2019) highlights the importance of this competency dimension for teachers in applied universities. Liu and Zhang (2024) utilized grounded theory to analyze 19 policy documents from the Ministry of Education of China and various provinces and cities regarding the transition of ordinary undergraduate colleges to applied universities, they found that applied teaching is a critical element for teachers to focus on during this transition, and conducting applied research for social service is a key factor for successful transformation. Zhao et al. (2023) based on the Outcome-Based Education (OBE) concept, surveyed 118 full-time teachers from eight applied private undergraduate universities in Shandong Province, and underwent reliability and validity analysis to construct an evaluation system for teachers at applied private undergraduate universities. The professional practice and social service indicators highlight the practical competency of teachers at applied universities. Professional practice indicators include employment and entrepreneurship guidance, professional skills, practical guidance, and construction of on-campus and off-campus bases. Social service indicators include social service, vocational guidance, and university-enterprise cooperation. Assigning teachers to internships in enterprises through school-enterprise cooperation is an effective approach to developing dual-teacher model teachers (Li 2020; Zhu 2024).

The literature review reveals the following findings: (1) The development of existing teacher competency measurement models predominantly relies on interview data and has undergone reliability and validity testing, which renders the measurement dimensions credible. However, there is no universally accepted model concerning these measurement dimensions. It is commonly agreed that teacher competency comprises a blend of abilities, including personality traits, knowledge, and skills. (2) Prior research has primarily concentrated on competencies within specific domains of university teaching, particularly focusing on teaching competency. Nonetheless, comprehensive competency models, especially for teachers in applied universities, are relatively underdeveloped. While the competencies of applied university teachers emphasize practical skills, the indicators for assessing practical competence remain insufficiently comprehensive. (3) There is an absence of competency models informed by recent data from applied universities in Anhui Province, resulting in an unclear understanding of the overall competency landscape among teachers in these institutions.

Overall, existing research lacks an integrated competency model that effectively addresses the core professional competencies of teachers in applied universities. Consequently, this study seeks to explore and integrate the measurement dimensions of teacher competency within the context of applied universities in Anhui Province, building upon existing models. This includes competencies related to personal characteristics, teaching, research, communication and cooperation, and practical competencies. The objective is to establish a comprehensive evaluation model for the competence of applied university teachers and to conduct an initial assessment of teacher competency levels in these institutions.

2.3 Comprehensive Competency Model for Applied University Teachers

Applied university teachers, like their counterparts in other types of universities, must possess certain

core professional competencies to facilitate their professional development. These competencies include personal characteristics, teaching ability, research skills, and communication and collaboration capabilities. However, applied university teachers also have distinct competency dimensions. They are not only academic personnel but also technical professionals or engineers, expected to apply these skills in teaching, research, and community service. According to the construction recommendations for applied universities in Anhui Province (Anhui Provincial Department of Education, 2020), at least 50% of teachers in each applied university should hold technical qualification certifications.

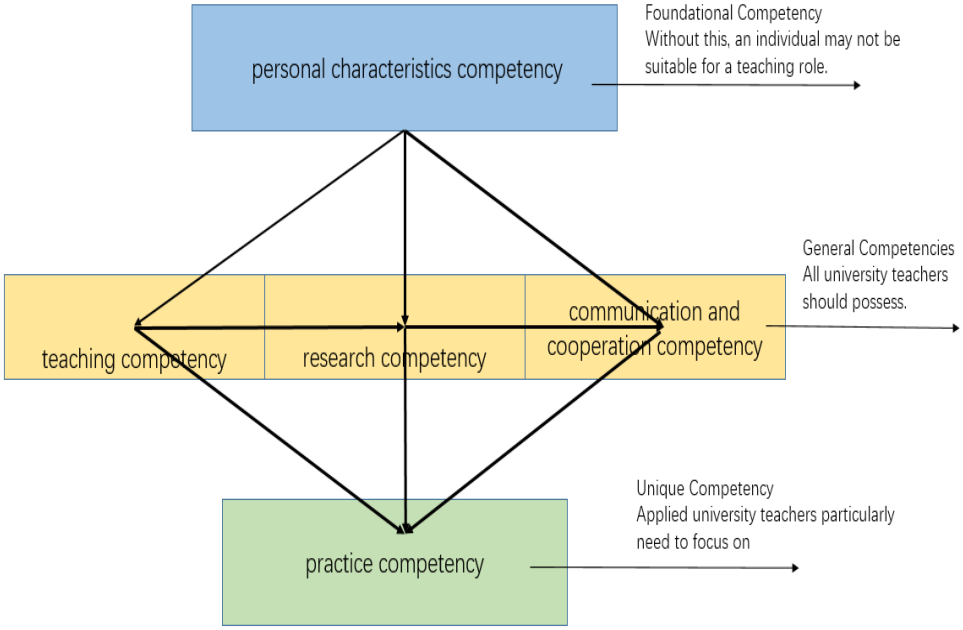

Figure 1. Core Professional Competency for Applied University Teachers.

Based on previous studies and the analysis of core professional competencies of applied university teachers (As shown in Figure 1), Personal Characteristics Competency is the foundational competency. Without this, an individual may not be suitable for a teaching role. Teaching Competency, Research Competency, and Communication and Cooperation Competency are general competencies that all university teachers should possess. Practice Competency is a unique competency that applied university teachers particularly need to focus on. Each of these competencies is interconnected, with personal characteristics competency serving as the base that supports the development and application of the other competencies, and practice competency aligning with the goals of cultivating talent in applied universities. Consequently, this study establishes the following first-level criteria: Personal Characteristics Competency, Teaching Competency, Research Competency, and Communication and Cooperation Competency, and Practice Competency (As is shown in Table 1).

Table 1. Basis of preliminary criteria construction.

first-level criteria	Main Reference Sources
Personal Characteristics Competency	Beyer, L. et al. (2022) ; Ministry of Education of PRC, 2020
Teaching Competency	Li et al. (2022); Teacher Digital Literacy Framework (2022)
Research Competency	Cao (2018)

Communication and Cooperation Competency	Blašková et al., 2014; Ministry of Education of PRC, 2020
Practice Competency	Lin et al., 2020 , Anhui Provincial Department of Education, 2020

3 Research Design

This section consists of the instrument development, the participants, the reliability test, and the validity test.

3.1 Instrument Development

As stated in the literature review, several domains of applied university teachers' competence are identified: personal characteristics competency, teaching competency, research competency, communication and cooperation competency, and practice competency. All the detailed behaviors are analyzed and compared; the same or similar behaviors were merged into one item, and behaviors inconsistent with our definition were deleted. Finally, we come up with a pool of potential scale items for each domain. A response format using a 5-point scale (1 = strongly disagree, 2 = relatively disagree, 3 = neutral, 4 = relatively agree, 5 = strongly agree) is adopted to measure teachers' competency. Sub-dimensions (sections) and the number of items in each sub-dimension are as follows:

(1) Personal Characteristics Competency: Personality, attitude, and professional ethics, consisting of 6 items.

(2) Teaching Competency: Teaching knowledge and methods, instructional design and feedback, consisting of 6 items.

(3) Research Competency: Research awareness, theories and methods, and research application, consisting of 6 items.

(4) Communication and Cooperation Competency: Communication skills and cooperation abilities, consisting of 5 items.

(5) Practice Competency: Practical teaching, industry experience, and social service, consisting of 6 items.

3.2. Pilot Test

3.2.1. Participants

A total of 122 applied university teachers, from a variety of specialties, in 2 universities in Anhui Province participated in our study from May 2023 to July 2023. All teachers were informed that their participation was voluntary, and the confidentiality of their responses was assured. Demographic characteristics are specified in Table 2.

Table 2. Polite Test Sample characteristics (N = 122).

Demographics		Number	Percentage (%)
gender	Male	64	51.6
	Female	58	48.4
Teaching Age	<5 years	30	24.6
	5-10 years	34	27.9
	11-20 years	32	26.2
	>20 years	26	21.3
Level of Education	PhD	17	13.9
	Currently pursuing a PhD	10	8.2
	Master	88	72.2
	Bachelor and Other	7	5.7

Professional Rank	Professor	15	12.3
	Associate Professor	43	35.2
	Lecture	34	27.9
	Teaching Assistance	30	24.6
University Category	Government	56	45.9
	Private	66	54.1

3.2.2. Reliability Test

Based on previous empirical research, the evaluation of each questionnaire item typically involves six key indicators. If any of the following characteristics are observed, the item should be revised or removed. (1) Missing data—when over 10% of the responses to a question are left blank; (2) Mean value—when the average response for a question exceeds 4.5 or falls below 1.5; (3) Skewness coefficient—when the absolute value of the skewness coefficient for a question is greater than 1; (4) t-test analysis—when the t-test for independent samples between high and low groups does not show a significant difference; (5) Correlation with overall score—when the correlation coefficient between the revised question and the total score is below 0.3; (6) Cronbach's alpha—when the Cronbach's alpha for a specific item is higher than the overall alpha coefficient of the questionnaire(Diao, 2022).

Drawing from the collected data, the findings of the item analysis are as follows: (1) Missing data—none of the 29 questions have missing values; (2) Mean value—the means of the 29 questions fall between 2.89 and 4.35; (3) Skewness coefficient—the coefficients range from −0.925 to 0.076, with all absolute values below 1; (4) t-test results—the t-test coefficients for the items have achieved a significant difference level (P = .000); (5) Correlation with overall score—the correlation coefficients between the items and the total score range from 0.437 to 0.859; (6) Cronbach's alpha—the Cronbach's alpha coefficient for the entire questionnaire is 0.964, with each first-level criterion's alpha coefficient being lower than 0.964 (see in Table 3). Thus, the scale demonstrates high reliability, and no items require removal.

Table 3. Reliability test.

First-Level Criteria	Items(N)	Cronbach's alpha
A Personal Characteristics Competency	6	.920
.B Teaching Competency	6	.942
C Research Competency	6	.917
D Communication and Cooperation Competency	5	.921
E Practice Competency	6	.836
Applied University Teachers' Competence Scale Total	29	.964

3.3. Data Collection

3.3.1 Sample Select

This research adopted a cross-sectional research design in which teacher competence at a particular time was investigated. The samples are of 6 applied colleges and universities situated in Anhui Province of China. The 6 implemented universities are in the north, center and south of Anhui Province in terms of geographical coverage. Regarding university types, 3 out of the 6 are government and 3 are private. In

the stratified random sampling approach, the strategy was the following: the applied universities in the Anhui Province were stratified by the geographical location (north, center, south) and the type of governance (government, private). Random sampling of the universities in each stratum was done to cover the stratum in a representative manner. Using power analysis, the sample size was estimated to be about 7 percent of fulltime faculty in each of the selected institutions conducted by calculating sufficient power to result in a statistical power of factor analysis and any other analysis. This was done systematically to provide both geographic and institutional variance as well as statistical rigor. See Table 4 for details.

Table 4. Details of the institutions surveyed

Institutions	Region	Government/ Private	Number	Proportion (%)
AHKJ	South	Government	67	19.4
WJG	South	Private	63	15.9
AHXH	Centre	Private	86	19.7
HFDX	Centre	Government	77	18.9
SZXY	North	Government	63	17.4
BBGS	North	Private	40	8.6

3.3.2 Data Gathering Procedures

Based on the scale, a questionnaire survey was conducted to analyze and investigate the competency level of teachers in the applied university. Larger amounts of sample data are used to analyze the characteristics of teachers' competence and classify teachers accordingly. The target group is the teachers of applied colleges and universities in Anhui Province, China. Stratified random sampling is adopted. The survey started in December 2023 and ended in May 2024. A total of 396 questionnaires were collected. The study eliminated the questionnaires if: (1) one or more items did not answer. This caused 4 questionnaires to be eliminated; (2) all items have the same answers, due to which 6 questionnaires were eliminated; (3) the outlies based on based on Mahalanobis distance; 5 questionnaires were deemed invalid because of this. After data cleaning, 381 responses were considered valid, the rate of effectiveness of the questionnaire being 96.2%.

3.4. Data Analysis

We used SPSS 24.0 and AMOS 24.0 to assess the measurement model. SPSS 24.0 was employed to conduct exploratory factor analysis (EFA) to extract appropriate measurement indicators and provide a more accurate conceptual understanding of those indicators (Sun and Zhou, 2005). Principal component analysis with varimax rotation was conducted using SPSS 24, where items with coefficients less than 0.5 or those that loaded on multiple factors (cross-loadings) were removed. Moreover, using SPSS 24.0 to examine reliability analysis. Cronbach' s alpha coefficients were used to evaluate the internal consistency of the scales. AMOS 24.0 was employed to conduct Confirmatory factor analysis (CFA) to assess the construction validity, discrimination validity and convergent validity of the measurement model. Several model fit indices were employed, including Chi-square degrees of freedom ratio ($\chi 2/df$), root mean square error of approximation (RMSEA), and comparative fix index (CFI). Following previous studies, a series of indicators were used to robustness of fit: $\chi 2/df < 3$, RMSEA < 0.08, and CFI > 0.90 (Wu, 2009). And composite reliability (CR) of the measurement models for each latent variable and average variance extracted (AVE) of the scale were examined, according to previous studies, CR>.70, AVE>.50 (Fornell and Larcker, 1981).

Self-reported data collection may lead to common method bias. Therefore, this study utilized the Harman single-factor method for examination, along with exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The EFA revealed that the first principal component accounted for

47.29% of the variance, which did not exceed the critical threshold of 50%. According to Podsakoff and Organ (1986), if the single factor extracted from EFA (without rotation) explains less than 50% of the variance, common method bias (CMB) is not considered serious. Subsequent CFA also indicated that the model fit indices did not meet the acceptable standards, suggesting that CMB is not a significant concern (Iverson and Maguire, 2000). Therefore, based on current standards, there appears to be no serious common method bias.

4 Empirical Findings

After data cleaning, a total of 381 valid questionnaires were retained for analysis.

4.1. Demographic Data

Among the 381 participants, 165 were male (43.3%) and 216 were female (56.7%), which aligns with the broader population of higher education institution (HEI) teachers in China, where females constitute the majority. The participants had varying teaching experiences: 119 were less than 5 years, 84 had between 5 and 10 years, 113 had between 10 and 20 years, and 65 had over 20 years of teaching experience. In terms of educational qualifications, 86 held PhDs (22.6%), 87 were currently pursuing a PhD (22.8%), 179 had master's degrees (47.0%), and 29 held bachelor's degrees or other qualifications (7.6%), with nearly half (47.0%) of the participants being master's degree holders. Regarding academic positions, there were 50 professors (13.1%), 115 associate professors (30.2%), 133 lecturers (34.9%), and 83 teaching assistants (21.8%). Additionally, 195 teachers (51.2%) were from government applied universities, while 186 teachers (48.8%) were from private applied universities. Table 5 presents the demographic characteristics of the participating teachers.

Table 5. Sample characteristics (N = 381).

Demographics		Number	Percentage (%)
Gender	Male	165	43.3
	Female	216	56.7
Teaching Experience	<5 years	119	31.2
	5-10 years	84	22.0
	11-20 years	113	29.7
	>20 years	65	17.1
Level of Education	PhD	86	22.6
	Currently pursuing a PhD	87	22.8
	Master	179	47.0
	Bachelor and Other	29	7.6
Academic Rank	Professor	50	13.1
	Associate Professor	115	30.2
	Lecture	133	34.9
	Teaching Assistance	83	21.8
University Category	Government	195	51.2
	Private	186	48.8

4.2. Exploratory Factor Analysis (EFA)

4.2.1. Validity Test

The sample adequacy for factor analysis was confirmed with a KMO value of 0.955, and Bartlett's test yielded a highly significant Chi-Square value of 8867.517 ($P<0.001$). According to Kaiser (1970), a KMO value exceeding 0.8 is required to confirm sample adequacy, while Bartlett's Test is considered valid if the Chi-Square value is significant (Bartlett, 1950). As all criteria were met, the scales used to assess

applied university teachers' competence can be reexamined using EFA. The extraction of factors was done based on principal component analysis (PCA) method and 29 items were loaded into 5 factors with reporting eigenvalues greater than 1, and total variance of the reported factors was 72.779%. It is implied that other non-extracted factors explain only a small amount of variance. Therefore, the model of applied university teachers' competence has been divided into 5 dimensions, which are named Personal Characteristics Competency (PCCO), Teaching Competency (TECO), Reacher Competency (RECO), Communication and Cooperation Competency (COCO), and Practice Competency (PRCO).

Then, 29 items were loaded with 5 common factors and all 5 common factors represented the respective variables. No cross loading appeared in the factor structure. One item was rejected from "personal characteristics competency" due to factor loading value less than 0.5, which meant poor factor loading. After the deletion of the item, the cumulative variance explained by the two rotated factors increased to 74.303%, indicating that the information contained in the study items can be effectively extracted. Therefore, the remaining 28 items were only considered in model of applied university teachers' competence. PCCO consists of 5 items (e.g. I can control my emotions and maintain composure when face pressure and challenges.), TECO consists of 6 items (e.g. I possess professional knowledge in the field of teaching subjects, and I am able to apply this knowledge in educational and teaching contexts.), RECO consists of 6 items (e.g. I have mastered the fundamental research methods in my field of study.), COCO consists of 5 items (e.g. I can communicate proactively and listen actively to others' opinions.), and PRCO consists of 6 items (e.g. I am capable of organizing and implementing practical teaching in courses, guiding students in professional practices, and fostering innovation and entrepreneurship.). The findings were summarized in table 6.

Table 6. Summary of EFA of the AUTC Scale

The scale was also extracted to state that 5 dimensions of competencies were supported with a VARIANCE of 74.3, thus showing a strong loading of all 28 items to five different dimensions.

Factors	SPSS Code	After Rotation			Communality
		Factor Loading	Eigenvalues	Variance Explained	
Personal Characteristics Competency (5 items)	PCCO		3.282	11.722%	
A1	PCCO 1	.742			.749
A3	PCCO 2	.700			.730
A4	PCCO 3	.717			.832
A5	PCCO 4	.668			.768
A6	PCCO 5	.655			.701
Teaching Competency (6 items)	TECO		4.297	15.346%	
B1	TECO 1	.687			.708

B2	TECO 2	.727			.774
B3	TECO 3	.686			.693
B4	TECO 4	.778			.807
B5	TECO 5	.793			.829
B6	TECO 6	.754			.695
Research Competency (6 items)	RECO		4.450	15.893%	
C1	RECO 1	.719			.736
C2	RECO 2	.745			.738
C3	RECO 3	.737			.668
C4	RECO 4	.760			.746
C5	RECO 5	.817			.778
C6	RECO 6	.737			.635
Communication and Cooperation Competency (5 items)	COCO		4.067	14.526%	
D1	COCO 1	.781			.695
D2	COCO 2	.784			.753
D3	COCO 3	.821			.788
D4	COCO 4	.829			.811
D5	COCO 5	.834			.784
Practice Competency (6 items)	PRCO		4.709	16.817%	
E1	PRCO1	.759			.706
E2	PRCO2	.836			.772
E3	PRCO3	.782			.707
E4	PRCO4	.734			.705
E5	PRCO5	.822			.784

E6	PRCO6	.763			.712
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy					.955
Bartlett's Test of Sphericity			Approx. Chi-Square		8727.174
			df		378
			Sig.		.000

After adjusting the scale items, KMO and Bartlett's Test were conducted again. The results are presented in Table 6. The KMO is 0.955, which is greater than 0.8. The result of Bartlett's sphericity test reaches a significant level. This indicates the data are suitable for exploration factor analysis (EFA) and confirmatory factor analysis (CFA)

4.2.2 Reliability Test

This study employs SPSS 24.0 to conduct an internal consistency reliability analysis using Cronbach's alpha coefficient. The Cronbach's alpha values for each first-level indicator and the overall scale are presented in Table 7. All Cronbach's alpha coefficient is above 0.9, meaning identified indicators accurately and consistently measure the respective variables (Sekaran and Bougie 2020).

Table 7. Reliability Testing

The value of Cronbach alpha of all dimensions is more than 0.90 and these are excellent indicators of reliability in the measurement of teacher competence.

	Number of items	Cronbach's Alpha
PCCO	5	.913
TECO	6	.929
RECO	6	.915
COCO	5	.920
PRCO	6	.924
Total Scale	28	.959

4.3. Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis (CFA) is used to confirm whether the questions contained in the questionnaire at all levels are in line with the original theoretical expectations. Structural equation modeling (SEM) software is used to verify and explore whether the factor structure of the questionnaire is compatible with the samples. According to the questionnaires based on core professional competency of applied university teachers, an SEM is established and tested by using AMOS 24.0.

First, the hypothetical model is established based on the relationships among constructs found in the exploratory factor analysis results, as shown in Figure 2. The $\chi 2/df$ value is 1.665, the comparative fit index (CFI) is above 0.9, and the RMSEA is 0.050. The model fitting effect is good (see Table 8). And the results show that the sample data can be well fitted to the five-dimensional factor model, thus verifying the validity of the structural framework of the questionnaire (Wu, 2009).

Table 8. Evaluation indicators of model fit.

Indicators	Reference Standards	Measured Results
$\chi 2/df$	<2 (excellent)	1.937
CFI	>0.95 (excellent)	.963
RMESA	<0.08 (good)	.050

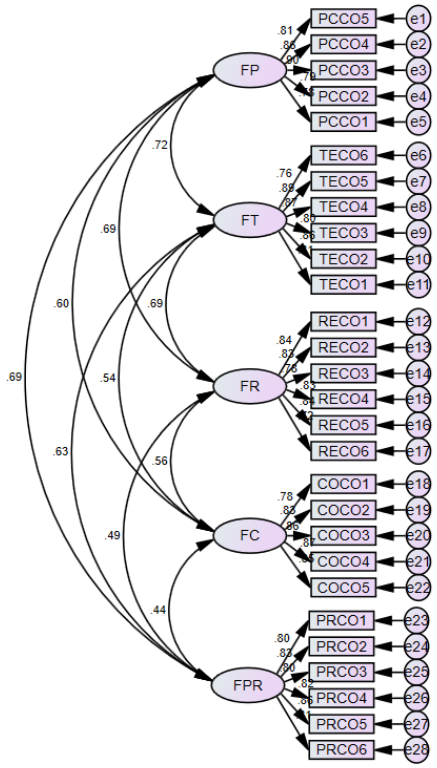

Figure 2. Five-dimensions model of applied university teachers' competence

Using AMOS 23.0 to examine composite reliability (CR) of the measurement models for each latent variable and average variance extracted (AVE), the results are displayed in Table 9. CR are all above 0.9, which meets the good level of 0.70. AVE are all above 0.6 and is above the recommended level of 0.5. As the results, the internal reliability of the measurement items is acceptable.

Table 9. Results of confirmatory factor analysis

Variables	Composite Reliability	Average Variance Extracted
PCCO	.92	.69
TECO	.93	.69
RECO	.92	.65
COCO	.92	.70
PRCO	.92	.67

Comparing square root of the AVE and its coefficients and the interrelationships between the latent variables to examine discriminant validity test of the applied university teachers' competence scale, the results are displayed in Table 10. The table shows that the square root of the AVE and its coefficients are greater than the interrelationships between the latent variables. Thus, the applied university teachers' competence scale has good discrimination validity.

Table 10. Discriminant Validity Test.

	PCCO	TECO	RECO	COCO	PRCO
PCCO	.69				
TECO	.673**	.69			
RECO	.653**	.673**	.65		

COCO	.565**	.499**	.517**	.70	
PRCO	.650**	.592**	.454**	.411**	.67
square root of the AVE	.83	.83	.81	.84	.82

Note: ** $p < 0.01$. AVE = average variance extracted.

The results of the confirmatory factor analysis indicate that the five-dimensional structure of comprehensive competency for teachers in applied universities, derived from exploratory factor analysis, has been effectively validated. The comprehensive competency of teachers in applied universities is primarily composed of five dimensions: Personal Characteristics Competency (PCCO), Teaching Competency (TECO), Research Competency (RECO), Communication and Cooperation Competency (COCO), and Practice Competency (PRCO). Each dimension comprises 5 to 6 indicators.

4.4. Descriptive Statistics

The average scores of the five competency categories calculated for the respondents (see Table 11) indicate that the competency levels of teachers in applied universities in Anhui Province are satisfactory. The scale employs a 5-point Likert scale, with a median of 3. The average scores for all five competency categories exceed 3, suggesting that the competency levels of teachers in Anhui Province are above the median. However, all averages are below 4, indicating that the competency levels across various dimensions are at a moderate level, with room for further improvement. Specifically, the average score for Practice Competency is the lowest, while the average score for Personal Characteristics Competency is the highest. Such patterns of competence give good information on applied development of the university. The low score of Practice Competency (3.66) also implies that the teachers require more industry experience and implementation of practical skills, and therefore they require better industry-academia collaboration. Good professional attitudes and moral principles are shown by the higher Personal Characteristics Competency scores (3.88). At a policy level, the focus of the institutional investments must be on practical training of skills, collaborations with industries and applied research opportunities to enhance the unique mission of applied universities

Table 11. Basic Descriptive Statistics of Teachers Competency

	N	Mean	SD
Personal Characteristics Competency (PCCO)	381	3.88	.76417
Teaching Competency (TECO)	381	3.71	.88686
Research Competency (RECO)	381	3.70	.87442
Communication and Cooperation Competency (COCO)	381	3.83	.86303
Practice Competency (PRCO)	381	3.66	.91591
Applied university teachers' competence (Average)	381	3.75	.69518

4.5 Differential Analysis

To further understand whether there are differences in each dimension of competency among teachers from different groups, the study will employ t-test and one-way ANOVA as the analytical tool. The analysis results are shown in Table 4.18. An independent samples t-test was conducted to examine the competence mean values between male and female teachers in applied universities in Anhui. The results indicated no significant difference in the organizational support between male and female teachers ($t = -1.019$, $p > 0.05$). Next, a one-way ANOVA was conducted to examine the competence mean values among teachers in applied universities in Anhui, categorized by different teaching experience, educational levels, and academic ranks. The results indicated no significant differences in organizational support

across different teaching experiences (F=1.857, p>0.05), educational levels (F=1.914, p>0.05) and academic ranks (F=1.268, p>0.05). Further, the results of an independent samples t-test, which examined the levels of competence among different types of applied university teachers in Anhui, revealed a significant difference between government university teachers and private university teachers (t = -2.745, p < 0.05). The mean value for private universities (M=3.95, SD=.04736) is higher than for public universities (M=3.71, SD=.05178).Competence scores did not differ significantly by gender, teaching experience, education level, and the academic rank indicating that the development of competence in applied universities could be shaped by an institutional ethos rather than the individual traits. Nonetheless, the high level of variance between the government and the private universities (-2.745, p<0.05) shows organizational structure and support systems are major contributors to development of teacher competence. Private universities can afford more freedom in professional development, a more direct relationship with the industry or can afford more favorable incentive schemes to encourage competence development. Alternatively, performance-oriented culture that pervades the working system of privately owned institutions is likely to propel the level of competence among the faculty.

4.6 Classification of the applied university teachers

This study aims to categorize sample teachers into distinct groups based on their total competency scores through cluster analysis, facilitating a clearer description and comparison of teaching competency levels across different types of teachers. Firstly, To assess the overall competency scores of the respondents, a weighted calculation of the composite score is employed, represented by the following formula:

$$Z = \sum_{n=1}^{5} a_n F_n$$

Let a_n(n = 1,2,3,4,5) represent the weights for each competency dimension, calculated based on their respective variance contribution rates, which are 11.72%, 15.35%, 15.89%, 14.53%, and 16.82%.

Secondly, to ensure that all variables exert a uniform influence on the cluster analysis, the data were standardized using Z-scores. This method converts each variable into a standard score, adjusting the mean to 0 and the standard deviation to 1. By doing this, it prevents variables with varying scales or ranges from disproportionately impacting the clustering results. The formula for calculating the Z-score is as follows:

$$Z = \frac{(X - \mu)}{\sigma}$$

X is the competency total score of each teachers; μ is the mean of all teachers' competence scores; σ is the standard deviation of all teachers' competence total scores.

Thirdly, the k-means clustering method was selected for this study, categorizing the teachers into four groups (see Table 12). From lowest to highest, their competency levels were classified as "Unsatisfactory," "Basic Competence," "Good," and "Excellent." Additionally, the results indicated significant differences among the categories (sig < 0.000), suggesting that the clustering outcomes are credible, as shown in Table 13.

Table 12. Clustering results.

	Clustering			
	1	2	3	4
Total Competence	1.02	-.57	.24	-2.30
Number	108	98	137	38

Competency based teacher classification has a convenient and usable system of specific professional

improvement and institutional strategy. By assigning the teachers to the clusters of competence, the administrators will be capable of designing the differentiated interventions: the group labeled as unsatisfactory (38 teachers) will need intensive remedial training focusing on competencies and foundations, whereas the group of basic competence (98 teachers) could use gradual skill-building programs. The high level of the category of Good (137 teachers) is a part of faculty that should be further prepared and possibly appointed to the positions of leaders, as the category of Excellent (108 teachers) should be used as mentors and leaders of professional development. The systematic classification turns the abstract measures in terms of competence into usable suggestions that human resource management can adopt, it allows professional development resources to be expended efficiently based on empirical measures other than subjective evaluation.

Table 13. ANOVA.

Total Competence	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
	117.407	3	.073	377	1611.447	.000

5 CONCLUSION AND DISCUSSION

Considering the recent demand for a tool to evaluate the competencies of teachers in applied colleges and universities, this study introduces the Applied University Teachers' Competence Scale, which is based on prior research and an examination of the essential professional competencies required for applied university educators. The initial scale consists of 29 items in 5 aspects. In the pilot study, an analysis of data from 2 applied colleges' teachers from Anhui Province confirmed the reliability of the scale. The study then collected data from a larger sample size for further analysis. Another 381 applied to university teachers from 6 colleges and universities in Anhui Province. After conducting a principal component analysis, one item with a factor loading below 0.5 was removed. The final scale consists of 28 items across five dimensions. The results reaffirmed the validity and reliability of the scale. This scale provides a rigorous assessment of the comprehensive competence of applied university teachers and offers recommendations for research in other provincial contexts. To the educational administrators, such a scale is a systematic framework of faculty evaluation and development planning. Institutions can plan specific programmes: remedial training of those who are judged to be Unsatisfactory, skill-building workshops to those in Basic Competence and small-groups, leadership development of Good and mentoring by those who are judged to have performed Excellent. The scale is also used in recruitment by creating gaps in competence.

To the policymakers, the results demonstrate that the institutional support mechanisms are very influential in possession of teacher competence. The faculty's performance may be improved due to the policies of industry-academia partnership, the elastic academic careers and competence-based assessment. The better score of competence in the case of the privately owned ones is an indication to keep the score and consider some performance-based incentives as well as free professional development in case of policy formulation. Firstly, we found that the weights assigned to the different dimensions of competency among applied university teachers vary. Practice competency has the highest weight, while personal characteristics competency is the lowest, with research competency slightly outweighing teaching competency. Our findings are valuable for understanding teachers' sustainable professional development from a competency perspective, enriching our theoretical understanding of the comprehensive competence of

applied university teachers. Additionally, this research contributes to competency theory by exploring critical factors in the evaluation mechanisms of applied university teachers. The development orientation and goals of applied universities differ from those of traditional undergraduate institutions, yet some teachers focus more on conducting research and publishing papers, neglecting the cultivation and improvement of their practical teaching abilities and social service skills. Establishing an evaluation and appointment system for applied university teachers that emphasize applicability, distinctiveness, and practicality plays a significant guiding and motivating role in building a strong applied teaching faculty.

We also found that the competency scores of applied university teachers in Anhui Province, both across various dimensions and overall, are at a moderately high level, indicating a generally satisfactory level of competence among these teachers. Additionally, differential analysis based on demographic information revealed that significant differences in overall competency levels exist only in relation to the type of institution, with no significant differences observed in relation to gender, years of teaching experience, educational background, or professional title. Researchers have found that organizational characteristics and institutional policies—such as science development policies, human resource development policies, management policies, and infrastructure development policies—positively impact teachers' professional development (Kálmán et al., 2020; Admiraal et al., 2021). According to organizational support theory, organizational support fosters positive organizational behavior among employees, leading to increased work engagement and improved job performance (citation needed). Our study also confirmed that different institutional structures result in variations in teacher competence within applied universities.

Another key discovery of this study is the categorization of teachers into four distinct groups based on their evaluation outcomes, with each group reflecting a different level of competency among applied university teachers. Identifying which category an applied university teacher falls into using this scale is crucial for supporting the ongoing development of both teachers and their institutions. This paper introduces a classification method that distinguishes applied university teachers by their competency characteristics across four dimensions, offering valuable insights for designing specialized training programs tailored to their needs. As noted by Popova et al. (2022), on-the-job training remains the primary strategy used globally to enhance the competence of practicing teachers, regardless of a country's economic status. Moreover, this scale provides a solid foundation for teachers' lifelong learning, enabling them to rapidly acquire and apply new skills, thereby enhancing the quality of education and advancing the sustainable development and transformation of applied education. When applied more broadly, this scale could contribute to establishing universal guidelines for the sustainable development of teachers.

This study is centered on developing a scale designed to evaluate and enhance the competence of applied university teachers and integrating it into educational practice. From a practical standpoint in educational development, the competence level of teachers plays a crucial role in determining the quality of talent cultivation. The study asserts that the high-quality growth of applied universities hinges on the availability of top-tier teaching resources. In the digital era, the rapid evolution of information technology has introduced swiftly changing industry demands and new challenges related to students' lifelong learning abilities. To meet these demands, it is essential to cultivate a greater number of exceptional teachers capable of adapting to and expanding the scope of education to meet new requirements. To effectively enhance the competence of applied university teachers, this study argues that a scientifically developed scale is essential for guiding educational management institutes in creating more effective teaching and training programs. Thus, the implementation of an applied university teachers' competence scale is closely intertwined with improving the quality of education and advancing sustainable development goals.

Future studies must investigate longitudinal competence development, the institutional influences on the resolution of competence, and the cross-validation of the scale in various contexts of different provinces and cultures. It is noteworthy that there are some limitations to this study, and further exploration will be conducted in the following areas: (1) Developing Competency Enhancement Training Programs Based on Empirical Data: With nearly 10% of respondents classified as inadequate, it is crucial for researchers and administrators to design targeted training programs that address the various dimensions of competency. These programs should focus on helping applied university teachers, particularly those with lower ratings, effectively improve their competency levels. (2) Investigating Organizational Factors Affecting Competency Performance: The study highlights that differences in organizational characteristics contribute to variations in competency performance. Researchers and administrators should analyze and compare the specific factors leading to these disparities—such as evaluation and promotion systems, compensation and benefits, and organizational climate—to provide organizational support that facilitates continuous competency development for teachers. (3) Addressing Limitations of **Self-Reported Data:** The outcomes of our study were based on self-reported data from teachers, which may introduce bias, particularly if some respondents were not entirely truthful or did not take the survey seriously. Future research could benefit from using a triangulation approach, gathering data from multiple sources, including administrators and students, to mitigate the limitations associated with self-report measures. There are various areas where immediate attention should be taken in policy implications, which include: (1) Establishment of competence-based faculty appraisal systems in applied universities, (2) Establishment of specific professional development systems based on empirically-obtained competence profile, (3) Establishment of partnership structures that exist between industries and academia to facilitate development of technically competent and practical faculty members, and (4) Institutionalization of support structures that facilitate continuous competence development among the faculty members.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

JY: Funding acquisition, Investigation, Data curation, Software, Writing-original draft. O-BK: Conceptualization, Formal analysis, Writing-review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict interest.

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