A Multidimensional Evaluation System for Research Competitiveness of Young Scholars in Higher Education Institutions

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Abstract

University talent evaluation has attracted considerable attention from various institutions in recent years. This paper establishes over 90 indicators across dimensions including academic achievements, funded projects, academic honors, research directions, international collaboration, awards, and academic part-time positions, forming a multi-dimensional evaluation system for the research competitiveness of young university scholars, and implements the system through programming languages with practical validation. This multi-dimensional evaluation system features comprehensive measurement of both the quality and quantity of academic achievements, enables comparison of scholars across different disciplinary fields, and emphasizes the assessment of scholars' potential, which can provide certain reference for the evaluation of young talents in related fields.

Full Text

Preamble

Research on a Multi-dimensional Evaluation System for Scientific Research Competitiveness of Young University Scholars

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Abstract This paper establishes a multi-dimensional evaluation system for the scientific research competitiveness of young university scholars by setting over 90 indicators across academic achievements, funded projects, academic honors, research directions, international collaboration, awards, and academic part-time positions. The system has been implemented and tested through programmatic development. Characterized by its comprehensive measurement of both the quality and quantity of academic outputs, its capacity for cross-disciplinary scholar comparison, and its emphasis on assessing scholarly potential, this evaluation system provides a valuable reference for evaluating young talent in relevant fields.

[**Keywords**] talent evaluation; evaluation system; scientific research competitiveness

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1 Research Background and Purpose

Scholars are the primary contributors to scientific research in universities and institutions, making the evaluation of their research competitiveness significant for talent recruitment, promotion decisions, and performance assessment. Young scholars, in particular, represent a crucial driving force for the future development of universities. An objective and effective evaluation system not only facilitates the formulation of incentive policies for young scholars but also benefits the long-term scientific development of institutions.

Domestic evaluation methods for university scholars have primarily focused on bibliometric indicators such as total publications, citation frequency, non-self citations, and the H-index, lacking a systematic and comprehensive indicator framework. Important dimensions closely related to research competitiveness—such as patent portfolios, funded projects, standard development, academic honors, and domestic/international collaboration—have rarely been incorporated or analyzed in existing research [**?**, **?**].

In recent years, international evaluations of university scholars have increasingly adopted Altmetrics indicators, which primarily measure click counts, downloads, shares, and comments from foreign online platforms and databases. These approaches focus on isolated aspects of academic influence rather than providing a holistic assessment. Moreover, such data typically originates from single-platform statistics, lacking comprehensive and systematic measurement, while some foreign platform data present challenges in accessibility and are underutilized by domestic scholars.

In response to China's current realities and the complex international environment, the Central Committee of the Communist Party of China and the State Council issued the "Overall Plan for Deepening Education Evaluation Reform in the New Era" [**?**], which emphasizes the principle of "breaking the five-only phenomenon" (the over-reliance on theses, titles, awards, projects, and credentials) in evaluation processes. In September 2022, the Ministry of Science and Technology, together with eight other departments, issued the "Work Plan for Pilot Reform of Science and Technology Talent Evaluation" [**?**], which stresses that talent evaluation should not rely solely on article counts or awards as single criteria. Instead, it should prioritize the completion of national tasks, particularly urgent and critical research missions, original scientific discoveries, major technological breakthroughs, practical technology transfer outcomes, and social benefit services as key components of innovation performance evaluation. The plan also advocates for an 代表作 evaluation system marked by original achievements and high-quality papers, establishing talent evaluation indicators that reflect major original contributions, national strategic needs, disciplinary characteristics, academic influence, and research capacity [**?**].

Addressing these policy directives and existing problems in domestic and international S&T talent evaluation, this study emphasizes the integration of quality and quantity in research output assessment, prioritizes high-level achievements, and considers disciplinary balance. Through a systematic approach, we have established first-level indicators across seven dimensions—academic achievements, funded projects, academic honors, research directions, international collaboration, awards, and academic part-time positions—comprising over 90 second-, third-, fourth-, and fifth-level indicators. Using bibliometrics, multi-dimensional statistical analysis, and expert surveys, we have developed a comprehensive evaluation system for university scholars' research competitiveness, which has been validated through practical application and can be implemented as an operational indicator-based evaluation system.

2 System Design

2.1 Design Principles

The multi-dimensional evaluation system was designed according to four core principles. First, **systematicity**: the indicator framework comprehensively examines all types of achievements obtained by young scholars while considering future development potential. The system encompasses over 90 indicators across seven dimensions—academic achievements, research directions, funded projects, academic honors, international collaboration, awards, and academic part-time positions. The design fully accounts for differences across departments, disciplines, and between engineering and science fields to ensure fairness and impartiality.

Second, **potential-oriented assessment**: the indicator system not only measures achieved outcomes but also estimates future research potential. For instance, the system evaluates publication trends over the past five years (increasing, stable/fluctuating, or decreasing) and examines the frontier nature of research topics in both papers and patents. International collaboration is also incorporated as it is widely recognized in the academic community as a factor contributing to high-impact research outcomes.

Third, **operability**: the indicator system was designed for practical evaluation activities. All selected indicators underwent repeated retrieval and testing in databases or platforms to ensure accessible and objective data availability. Subsequent data comparison and statistical analysis led to minor supplementation and removal of certain indicators.

Fourth, **extensibility**: considering the variability of evaluation targets and the potential for further indicator enrichment, the final program design is based on Python, which is flexible and easily modifiable. This foundation prepares the system for future application to different types of evaluation subjects while ensuring data accuracy and reducing manual errors.

2.2 Indicator Framework

2.2.1 First-Level Indicators The talent evaluation system integrates multiple factors related to talent assessment, ultimately establishing seven first-level indicators: academic achievements, research direction, funded projects, academic honors, international development, awards, and academic part-time positions [Figure 1: see original paper].

2.2.2 Multi-level Indicators Under First-Level Indicators Academic Achievements. As shown in [Figure 2: see original paper], the academic achievements indicator comprises four second-level indicators: SCI/SSCI publications, patents, monographs, and standards.

For SCI/SSCI publications, data were retrieved from the Web of Science platform by Clarivate Analytics, covering essentially all publications in a scholar's career, including cases of institutional changes or overseas study experiences. After retrieval, the Incites analytical tool was used to extract various metrics. Publication scale indicators include: total publication count (Article and Review document types from Web of Science's SCI/SSCI sub-databases), first-author percentage, and corresponding-author percentage (both from Incites' people analysis). Publication trend is categorized as increasing, stable/fluctuating, or decreasing based on publication counts over the past five years. Journal quality indicators include: CNS journal count (publications in *Cell*, *Nature*, and *Science* and their sub-journals) and Q1 journal percentage (from Incites' people analysis). Impact indicators include: average citations per paper (total citations divided by publication count, with total citations from Incites), CNCI values, top 1% highly cited paper percentage, top 10% highly cited paper percentage, and H-index excluding self-citations (all from Incites). The CNCI (Category Normalized Citation Impact) metric, recently adopted by Clarivate, is calculated by dividing actual citations by expected citations for documents of the same type, publication year, and subject field, enabling cross-disciplinary comparison by eliminating disciplinary and temporal biases. The H-index excluding self-citations enhances objectivity in inter-scholar comparisons.

Patent data were retrieved from the Incopat patent database using scholars' names and institutions as search terms, with manual removal of duplicate names. Patent impact indicators include: high-value patent percentage (ratio of patents with Incopat value scores exceeding 8 points to total patent applications) and average value of top ten high-value patents (mean Incopat value score of the top ten patents). The Incopat value score is a comprehensive patent evaluation metric ranging from 1 to 10, with 10 being the highest, assessed across over 20 parameters including technical stability, advancement, and protection scope.

Monograph data were primarily retrieved from the National Library of China and Duxiu academic search engine, with 120 important publishers identified through expert consultation. Monograph citation frequency data were obtained from Duxiu. Standard data were retrieved from the CNKI Standards Database and NSTL (National Science and Technology Library) Standards Database using drafter information.

Research Direction. This dimension examines the frontier nature of research topics from both paper and patent perspectives. Hot paper count and highly cited paper count were obtained from Incites' people analysis, while emerging industry patent percentage was derived from the Incopat database [Figure 3: see original paper].

Funded Projects. This indicator examines publicly retrievable funded projects where the scholar serves as principal investigator, including National Natural Science Foundation projects, National Key R&D Program projects, National Social Science Fund projects, and other funded projects [Figure 4: see original paper].

Academic Honors. This category includes talent titles, professional ranks, and mentorship qualifications. Talent titles encompass both domestic and international honors such as IEEE Fellow and Clarivate/Elsevier Highly Cited Researcher recognitions [Figure 5: see original paper].

International Development. This dimension assesses international collaboration scale through the number of foreign co-authors in SCI/SSCI publications. It also identifies the highest ranking among the top three partner institutions using the ShanghaiRanking's Academic Ranking of World Universities 2022, and similarly identifies the highest-ranked non-university research institutions with international collaboration using the ESI database, taking the higher of the two values [Figure 6: see original paper].

Awards. This indicator includes publicly retrievable major awards, with scores assigned based on level and quantity to ensure fairness [Figure 7: see original paper].

Academic Part-time Positions. This indicator covers scholars' roles as editors, editorial board members, or reviewers in important journals, as well as their participation as chairs in major domestic and international academic conferences. Information was sourced from the CNKI database and scholars' personal webpages [Figure 8: see original paper].

2.3 Weight Coefficients and Measurement Scales

Following the establishment of the evaluation system, weight coefficients and measurement scales were developed through discussions among senior librarians, consultation with domain experts, comprehensive statistical analysis of retrieved data, and reference to scoring mechanisms from ShanghaiRanking's world university evaluation indicators and metrics from Clarivate and Elsevier Highly Cited Researchers [?]. provides examples of weights for first- and some second-level indicators, where the sum of weights for all indicators at each level equals 1. For the second-level indicators under academic achievements, considering that schools 偏向 humanities and management produce fewer standards, the higher value between monographs and standards is taken.

illustrates measurement methods for third- to fifth-level indicators. Each indicator's maximum score is 10 points, with scores calculated progressively from lower to higher levels based on the scales provided.

3 Selection of Research Subjects

This study selected 33 in-service scholars under 35 years old from Harbin Engineering University in 2022 for comprehensive information retrieval and evaluation using the established system. To test data coverage and disciplinary applicability, the selected scholars included not only those from the university's key "Three Seas and One Nuclear" schools (such as the School of Shipbuilding Engineering and the School of Power and Energy Engineering) but also scholars from basic science-oriented schools like the School of Materials Science and Engineering and the School of Physics and Optoelectronics Engineering. Additionally, three scholars from the School of Economics and Management were evaluated, covering all schools except humanities, social sciences, and Marxism studies.

4 Implementation of the Talent Evaluation Scoring System

To reduce manual operations, ensure accuracy, and enable broader future applications, this study employed the popular Python programming language for system development. Using the PyQt module to build the software interface and writing over a thousand lines of code, we independently developed the talent evaluation scoring system shown in [Figure 9: see original paper]. By inputting retrieved numerical values, percentages, and binary information (represented by 1 for yes and 0 for no), the program automatically converts and calculates scores based on built-in measurement scales and conditional statements, ultimately generating comprehensive evaluation scores for subjects efficiently and accurately.

5 Evaluation Results and Analysis of Young Scholars

Through data analysis across the seven indicator dimensions for 33 young scholars, the final scores followed a normal distribution: 1 scholar scored above 7 points, 6 scored between 6-7 points, 8 scored between 5-6 points, 5 scored between 4-5 points, 8 scored between 3-4 points, and 5 scored below 3 points.

Score interpretation is as follows: **6 points and above** indicates excellent performance across all indicators with comprehensive development. These scholars possess significant potential and should be prioritized for institutional incentives, as they are likely to produce greater quantities of higher-quality research. For external candidates, direct recruitment is recommended. **5-6 points** indicates relatively excellent performance, suggesting scholars warrant intensified institutional support and will likely produce more research outcomes. **4-5 points** indicates good performance with expected future productivity; these scholars should receive institutional attention and are encouraged to identify breakthrough research directions. **3-4 points** indicates qualified performance with potential weak areas; scholars should continue developing strengths while addressing deficiencies. **Below 3 points** indicates multiple weak areas with substantial room for improvement; scholars should focus on learning from high-achieving peers to enhance their comprehensive research capabilities.

6 Conclusions and Recommendations

Based on practical exploration and implementation of this evaluation system, two primary conclusions emerge. First, the system achieves balanced quality-quantity measurement. For example, one scholar with 135 SCI publications received a lower comprehensive score than a peer with only 40 SCI publications, as the latter achieved 41 average citations per paper with all publications in Q1 journals and patents concentrated in emerging industries. This demonstrates that the rational indicator design ensures simultaneous consideration of quality and quantity.

Second, the system enables cross-disciplinary scholar comparison. It incorporates discipline-normalized indicators such as CNCI and simultaneously retrieves SCI and SSCI publications to ensure coverage of science, engineering, and management disciplines. Certain indicators, such as taking the higher value between monographs and standards, enhance comparability between scholars from different fields, including engineering versus basic sciences and engineering versus management.

Problems and Recommendations: First, the evaluation system favors scholars with comprehensive information across all seven dimensions. Some information is sourced from scholars' personal webpages, and incomplete information may affect scores. If applied to talent recruitment, scholars should be encouraged to provide complete information to ensure evaluation accuracy. Second, the current system is primarily designed for evaluating young university scholars and is better suited for engineering and management backgrounds. For other groups, such as humanities and social sciences scholars or mid-to-late-career researchers, some indicators or measurement scales may require adjustment.

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