Research on the Measurement of Entrepreneurship Competence of University Students at Guangzhou Institute of Science and Technology Based on Machine Learning

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Abstract. Against the backdrop of the national innovation-driven development strategy and the popularization of higher education, this study focuses on Guangzhou Institute of Science and Technology, a representative private institution in Guangdong Province, to systematically review research progress on entrepreneurial competency theory and evaluation methods. This study employs machine learning as its technical foundation to construct a fuzzy evaluation system comprising four dimensions—entrepreneurial cognitive ability, entrepreneurial technical ability, entrepreneurial character and literacy, and resource integration ability—with 16 secondary indicators. The Delphi method was used to calculate indicator weights, and empirical evaluation was conducted using questionnaire survey data. An integrated learning algorithm trained on sample data constructs a predictive model for entrepreneurial competency among university students, revealing the influence weights and nonlinear correlations of each indicator on competency. Findings indicate that Guangzhou Institute of Science and Technology students exhibit overall moderate entrepreneurial competency, with notable deficiencies in resource integration and risk management skills. Significant clustering patterns emerge in competency differences across majors and grade levels. Based on feature importance analysis from the machine learning model and aligned with the university's innovation and entrepreneurship education practices, targeted cultivation pathways are proposed across four dimensions: curriculum optimization, practical platform upgrades, faculty development, and support mechanism refinement. This provides an intelligent solution offering both theoretical reference and practical insights for enhancing entrepreneurial competency among students at private universities in Guangdong Province.

Keywords: Private Universities, University Student Entrepreneurial Competence, Machine Learning, Fuzzy Evaluation, Guangzhou Institute Of Science And Technology

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1 Introduction

China's economy has transitioned from a phase of rapid growth to one of high-quality development, where innovation and entrepreneurship serve as the core engines driving economic restructuring and upgrading while stimulating market vitality. The State Council's "Guiding Opinions on Further Supporting University Students' Innovation and Entrepreneurship" (State Council Document [2021] No. 35) explicitly calls for integrating innovation and entrepreneurship education throughout the talent cultivation process, focusing on enhancing students' innovative spirit, entrepreneurial awareness, and entrepreneurial capabilities. As a frontier of reform and opening-up, Guangdong Province boasts high economic dynamism and distinct industrial cluster advantages, offering an excellent market environment and development opportunities for student entrepreneurship.

Private universities constitute a vital component of China's higher education system. By 2024, Guangdong Province had over 50 private institutions with more than 1.2 million enrolled students, demonstrating unique strengths in cultivating applied and skilled talents. However, compared to public universities, private institutions still face gaps in educational resources, faculty strength, and societal recognition, presenting numerous challenges in developing students' entrepreneurial competencies. As a representative private applied undergraduate institution in Guangdong, Guangzhou Institute of Science and Technology has actively responded to national strategies in recent years. It introduced the Implementation Plan for High-Quality Development of Innovation and Entrepreneurship Education[1], establishing a "whole-person, whole-process, whole-spectrum" innovation and entrepreneurship education framework. Nevertheless, systematic research on evaluating and precisely cultivating entrepreneurial competence remains lacking.

Entrepreneurial competence serves as the core element for university students to engage in entrepreneurial activities and enhance their success rates, yet its evaluation process exhibits characteristics of fuzzy uncertainty and complexity. Traditional evaluation methods struggle to scientifically and reasonably reflect the true level of entrepreneurial competence among students in private universities, particularly when it comes to quantitatively measuring the varying degrees and strengths of this competence. What are the systemic shortcomings in the entrepreneurial capabilities of private university students? Does participation in innovation and entrepreneurship practices genuinely enhance their competence? These questions remain largely unanswered by targeted empirical research. Therefore, this study introduces a fuzzy multi-criteria evaluation model to construct a scientifically sound evaluation framework. Using Guangzhou Institute of Science and Technology as a case study, it empirically investigates the structural characteristics and primary shortcomings of entrepreneurial competence among private university students, tests the effects of practical participation, and proposes targeted cultivation strategies. This research holds significant theoretical value and practical implications for enhancing the quality of innovation and entrepreneurship education in Guangdong's private universities and promoting high-quality entrepreneurial employment among university students.

2 Literature Review

Using the core keywords entrepreneurial competence, university student entrepreneurial ability, fuzzy evaluation, and private university, this study searched core journal articles from databases such as CNKI and VIP from 2022 to 2025. It systematically reviewed key research findings on defining entrepreneurial competence, constructing evaluation systems, applying evaluation methods, and developing cultivation strategies for private universities, thereby establishing the theoretical foundation for this research.

2.1 Research on Defining the Connotation of Entrepreneurial Competence

While academia has yet to reach a unified definition of entrepreneurial competence, a core consensus is emerging. Research focus has shifted from singular entrepreneurial skills and traits to multidimensional comprehensive assessments. Li Xiang et al. (2025) proposed that entrepreneurial competence is the integrated ability to mobilize resources, manage risks, and achieve goals during the entrepreneurial process, encompassing three core dimensions: entrepreneurial cognition, skills, and qualities[2]. Yi Xin (2021) further expanded this framework, arguing that the digital economy necessitates incorporating digital technology application and cross-boundary integration capabilities—a perspective widely endorsed by scholars[3]. For students in private universities, Cui Yuan (2024) emphasize the applied nature of entrepreneurial competence, highlighting practical operation, resource integration, and market adaptability[4]. They define it as an organic unity of four dimensions—cognition-skill-quality-resource—providing a key reference for constructing the indicator system in this paper.

2.2 Research on the Construction of Entrepreneurial Competence Evaluation Systems

The evaluation indicator system is the core prerequisite for assessing entrepreneurial competence, with scholars constructing diverse systems based on different perspectives. Zhu Ying (2020) extracted 52 initial elements through behavioral event interviews, then screened 31 core elements via factor analysis to construct a comprehensive six-dimensional system encompassing entrepreneurial motivation and skills[5]. Addressing the unique context of private universities, Silina et al. (2022) removed theory-heavy indicators and added applied metrics like practical project participation to enhance the system's relevance[6]. Lu Yan (2024) developed an outcome-based framework grounded in OBE principles, emphasizing alignment between indicators and educational objectives/societal demands while integrating process and outcome evaluations[7]. Overall, existing frameworks show a transition trend from "comprehensive→ targeted" and "theoretical→ practical." However, personalized systems tailored to specific private universities remain scarce,

particularly those integrating Guangdong's regional industrial characteristics and institutional disciplinary strengths, which are still in their infancy.

2.3 Application Research on Entrepreneurship Competency Evaluation Methods

Entrepreneurial competency evaluation involves inherent ambiguity and subjectivity, making traditional quantitative methods inadequate for accurately reflecting actual levels. Emerging approaches like fuzzy evaluation methods and the Analytic Hierarchy Process (AHP) have gained widespread application in recent years. Liu Rongzhi et al. (2020) applied the Intuitive Fuzzy AHP to evaluate University Students' entrepreneurial competencies, quantifying fuzzy criteria through hierarchical models to enhance evaluation rigor[8]. Zhang Qian et al. (2025) compared fuzzy comprehensive evaluation with BP neural network models, confirming the former's advantages in operational simplicity and intuitive results when addressing multidimensional fuzzy evaluation problems, making it suitable for routine assessment needs in private universities[9]. Li Shuzhou et al. (2020) introduced the entropy weight method to optimize fuzzy evaluation models, reducing the influence of expert subjective judgments and further enhancing evaluation objectivity[10].

2.4 Research on Strategies for Cultivating Entrepreneurial Competence Among Undergraduates in Private Universities

Scholars have proposed multi-dimensional recommendations for cultivating entrepreneurial competence among students in private universities. At the curriculum level, Jia Zheng et al. (2023) advocated deepening the integration of specialization and entrepreneurship, identifying innovative elements within professional courses, and leveraging projects to enhance practical skills[11]. Regarding practical platforms, Yi Ting et al. (2023) recommended that private universities integrate social resources to strengthen industry-academia collaboration, jointly establish practical incubation bases, and utilize innovation and entrepreneurship competitions to "promote learning through competition and foster innovation through competition," thereby enhancing students' real-world capabilities[12]. Regarding faculty development, Qin Na et al. (2025) advocated building a combined full-time and part-time faculty team, strengthening entrepreneurship training and corporate internships for full-time instructors, and appointing outstanding external talents as entrepreneurial mentors to provide comprehensive guidance services[13].

2.5 Application of Machine Learning in Entrepreneurial Competence Evaluation

Machine learning methods have recently been introduced into entrepreneurial competence research, offering advantages in capturing complex nonlinear relationships within multidimensional data. LI Hongyan et al. (2024) applied support vector machines to classify students' entrepreneurial potential, achieving 86.3%

accuracy using 21 features covering psychological, skill, and environmental dimensions[14]. Chen Chengmeng et al. (2023) compared five algorithms and found that ensemble methods like XGBoost outperformed single classifiers, with an F1 score of 0.892 in predicting entrepreneurial intention[15]. Wenwen Zhao et al. (2024) combined Delphi with back propagation neural networks to develop a hybrid evaluation model, achieving a mean absolute error of 0.127[16]. Puying Li (2025) employed unsupervised learning to identify four distinct competency profiles among 1,856 students, revealing heterogeneity in entrepreneurial readiness[17]. However, existing studies focus on prediction rather than systematic measurement, overlook private university contexts, and rarely integrate machine learning with frameworks like fuzzy evaluation.

In summary, research on entrepreneurial competence has yielded substantial outcomes, generating valuable conclusions regarding conceptual definition, evaluation system construction, assessment method application, and cultivation strategies. However, existing research still exhibits the following limitations: First, personalized studies on entrepreneurial competence among students in private universities are scarce, particularly empirical research grounded in specific institutional cases. Second, while various assessment methods have been applied, traditional approaches often rely on subjective weighting and linear assumptions, limiting their capacity to capture complex nonlinear patterns in competency data; furthermore, the regional adaptability of evaluation indicator systems requires improvement, with a lack of frameworks tailored to Guangdong Province's industrial characteristics and the positioning of private universities. Third, cultivation strategies predominantly offer generic recommendations, necessitating reevaluation of their specificity and practicality.

The innovative aspects and marginal contributions of this study are primarily reflected in the following areas: ① Innovative Points: First, grounded in the positioning of private universities and the regional industrial characteristics of Guangdong, this study focuses on the undergraduate population of Guangzhou University of Technology. It constructs an entrepreneurial competency evaluation index system that is targeted, practical, and regionally adaptable, addressing the shortcomings of existing research in terms of insufficient case studies and lack of distinctiveness. Second, it organically integrates traditional fuzzy evaluation with machine learning methods, optimizing weight allocation and assessment accuracy to effectively reduce subjective bias and enhance the scientific rigor and intelligence of the measurement model. Third, it establishes a closed-loop approach of "measurement-diagnosis-enhancement," providing actionable empirical evidence and improvement directions for the university's entrepreneurship education. ② Marginal Contribution: Theoretically, this enriches the methodological framework for evaluating entrepreneurial competency among students at private universities and expands the application of machine learning in entrepreneurial assessment. Practically, it precisely identifies gaps in students' entrepreneurial capabilities, providing empirical support for Guangzhou Institute of Science and Technology to optimize its specialized-entrepreneurship integration curriculum, strengthen practice-

based education, and refine cultivation mechanisms. It also offers valuable reference for similar local private universities.

3 Construction of Fuzzy Evaluation Models and Design of Machine Learning Algorithms

3.1 Model algorithm design

To quantitatively describe entrepreneurial competence among university students at Guangzhou Institute of Science and Technology, a fuzzy multi-criteria decision-making model is employed to measure the fuzzy uncertainty inherent in the problem, thereby providing a quantitative description of entrepreneurial competence. However, when factors are excessive or their interactions involve hierarchical levels, the "$\wedge - \vee$" operator proposed by Zadeh may lead to "extinction" phenomena, yielding meaningless results. To prevent valuable information loss, we adopt a multi-level fuzzy measurement model. This model effectively substitutes factor (or weight) segmentation with hierarchical segmentation.

Measuring entrepreneurial competence among university students at Guangzhou Institute of Science and Technology often requires considering numerous factors with varying categories and hierarchical levels, necessitating a multi-level measurement model.

Definition: Given a set *U*, let *P* denote a partition of *U* into *k* subsets satisfying:

① $\bigcup_{i=1}^{k} U_i = U$;

② $U_i \cap U_j = \varnothing, \forall i, j, i \neq j$.

Then *P* is termed a partition of U, denoted as: $U / P = \{U_1, U_2, \cdots, U_k\}$.

The multi-level measure model can be implemented through the following steps:

(1) Partition the factor set $U = \{u_1, u_2, \cdots, u_k\}$ into P, yielding: $U / P = \{U_1, U_2, \cdots, U_k\} = \{U_i\}, i = 1,2, \cdots, k$, where U_i contains n_i factors, denoted as: $U_i = \{u_{i_1}, u_{i_2}, \cdots, u_{i_{n_i}}\}$.

Clearly, we have: $\sum_{i=1}^{k} n_i = n$

(2) For each U_i , i.e., each group, apply fuzzy measure using a single-level measure model: $B_i = A_i \circ R_i, (i = 1,2, \cdots, k)$

(3) Construct a higher-level fuzzy matrix from

$$B_i(i=1,2,\cdots,k) : R=\begin{pmatrix} B_1 \\ B_2 \\ \vdots \\ B_k \end{pmatrix}$$

Let the weight vector of $U_1,U_2,\cdots,U_k$ be $A=(a_1,a_2,\cdots,a_k)$, satisfying: $\sum_{i=1}^{k} a_i = 1$

Then the second-level measure model is:

$$B = A \circ R = A \circ \begin{pmatrix} A_1 \circ R_1 \\ A_2 \circ R_2 \\ \vdots \\ A_k \circ B_k \end{pmatrix} = (b_1, b_2, \cdots, b_m)$$

Since the " $\wedge - \vee$ " (min-max) operator in $B = A \circ R$ has certain limitations (Chen Shouyi, Liu Yunfeng, Wang Peizhuang: Mathematical Models for Comprehensive Evaluation, Fuzzy Mathematics, 1983, pp. 61-70), the " $\wedge - \vee$ " operator is extended to a more general composite operation. There are typically four types: ① $M(\wedge,\vee)$ "Main Factor Determining Operator"; ② $M(\bullet,\vee)$ "Main Factor Emphasizing Operator"; ③ $M(\wedge,\oplus)$ "Uneven Moderate Operator", where: $\alpha \oplus \beta = \min(1, \alpha+\beta)$ (Bounded Sum); ④ $M(\bullet,+)$ "Weighted Moderate Operator", i.e., conventional matrix multiplication. This operator ensures each factor contributes to the comprehensive evaluation. $b_j = \sum_{i=1}^{k} a_i \bullet r_{ij}, j=1,2,\cdots,m$, where: $\sum_{i=1}^{k} a_i = 1$, requiring weight normalization.

U={u_1, u_2,u_3,u_4} , $\underset{\sim}{A}$={a_1,a_2,a_3,a_4} .

Calculation of membership degrees for each secondary evaluation indicator level regarding factors influencing entrepreneurial competence among students at Guangzhou Institute of Science and Technology.

(4) Assign corresponding weight values to the four influencing factors (evaluation indicators) based on their importance in industrial operations, denoted as the weight set:

$\underset{\sim}{A}=\{a_1, a_2, a_3, a_4\}=(0.22, 0.28, 0.25, 0.25)$. Given the practical significance of this problem, the $M(\bullet,+)$ operator, i.e., the "weighted Moderate" operator, is selected. This yields the fuzzy subset B on V .

In summary, when applying the above operators, one should select the appropriate operator based on the specific problem. It must be capable of describing the essence of the actual problem to achieve satisfactory results, while ensuring that $B=(b_1,b_2,\cdots,b_m)$ satisfies $b_j \in [0,1](j=1,2,\cdots,m)$.

3.2 The Steps of Fuzzy Evaluation of University Students' Entrepreneurship Ability

The Delphi method, also known as the expert survey method, is a systematic decision-making and forecasting approach that leverages expert knowledge and experience through anonymous correspondence. Its core characteristics are anonymity, multiple feedback rounds, and statistical convergence. By distributing questionnaires to independent experts across multiple rounds, the opinions from each round are aggregated, organized, and statistically analyzed before being fed back to all experts. This process guides experts to revise their individual views based on collective judgment. Through repeated cycles, opinions gradually converge and unify, providing scientific and reliable grounds for research tasks such as indicator selection, plan evaluation, and future forecasting. That is, Delphi Method = Anonymous + Multiple Rounds + Back-to-Back Expert Survey The core principle is: preventing experts from influencing each other, iteratively converging opinions, and achieving a relatively reliable consensus.

(1) Define evaluation levels: Based on the actual circumstances of university student entrepreneurial competency, establish five evaluation levels: Excellent (*V*1, 90-100 points), Good (*V2*, 80-89 points), Moderate (*V3*, 70-79 points), Below Moderate (*V4*, 60-69 points), Poor (*V5*, <60 points).

(2) Establish the Fuzzy Evaluation Matrix: Collect data through questionnaires to calculate the membership degrees of each indicator across different evaluation levels, constructing the fuzzy evaluation matrix R. Here, r_{ij} represents the degree to which indicator i belongs to evaluation level j , satisfying the condition: $\sum_{i=1}^{16}\sum_{j=1}^{5} r_{ij}=1$ $(i=1,2,\cdots,16; j=1,2,\cdots,5)$.

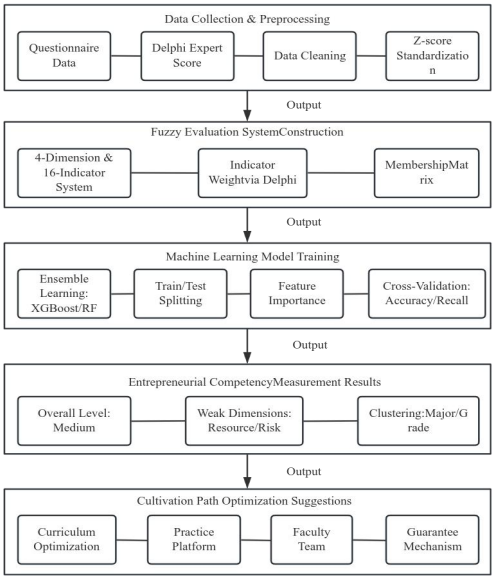

Fig. 1. Machine Learning Algorithm Design Diagram for Measuring Entrepreneurial Competence Among University Students at Guangzhou Institute of Science and Technology

(3) Fuzzy comprehensive evaluation calculation: Employ the weighted Moderate method for fuzzy comprehensive evaluation, calculated as $B=W\times R$, where B is the fuzzy comprehensive evaluation result vector and W is the indicator weight vector. Determine the comprehensive evaluation grade for Guangzhou Institute of Science and Technology students' entrepreneurial competence based on the maximum membership principle.

In summary, the machine learning algorithm design diagram for the study on measuring entrepreneurial competency among college students at Guangzhou Institute of Science and Technology has been obtained (see Figure 1).

4 Empirical Study on Fuzzy Evaluation of Entrepreneurial Competence Among Undergraduates at Guangzhou Institute of Science and Technology

4.1 Overview of the Study Subjects

The fuzzy evaluation of entrepreneurial competence among Guangzhou Institute of Science and Technology students involves numerous factors, making this research a complex systematic project. It requires adherence to the principles of constructing evaluation indicator systems. Professors in entrepreneurship management, the head of innovation and entrepreneurship education at Guangzhou Institute of Science and Technology, and corporate entrepreneurship mentors were invited to screen and refine the evaluation indicators for student entrepreneurial competence. By reviewing

existing research and integrating Guangzhou Institute of Science and Technology's specific context, the indicators were validated for scientific rigor, systematic coherence, and practical applicability. This culminated in the finalization of an evaluation framework comprising one primary indicator, four first-level indicators, and sixteen second-level indicators, along with their respective weight values (see Table 1 and Figure 2).

Table 1. Guangzhou Institute of Science and Technology University Student Entrepreneurship Competency Evaluation Indicator System and Weight Values

Goal Evaluation Indicator	Primary Evaluation Indicators	Weight Value	Second-Level Evaluation Indicators	Weight Value
University Student Entrepreneurship Competency (A)	Entrepreneurial Cognitive Ability (A_1)	0.22	Entrepreneurial Policy Judgment Ability (A_{11})	0.058
			Industry Development Analysis Ability (A_{12})	0.062
			Entrepreneurial Risk Identification Ability (A_{13})	0.055
			Mastery of Entrepreneurial Laws and Regulations (A_{14})	0.045
	Entrepreneurial Technical Capabilities (A_2)	0.28	Business Plan Writing and Operational Skills (A_{21})	0.072
			Market Research and Technical Analysis Capability (A_{22})	0.075
			Team Coordination and Communication Collaboration Capability (A_{23})	0.068
			Risk Response, Prevention, and Control Capabilities (A_{24})	0.065
	Entrepreneurial Quality Literacy (A_3)	0.25	Entrepreneurial Motivation and Values (A_{31})	0.068
			Innovative Mindset and Perseverance (A_{32})	0.072
			Entrepreneurial Stress Coping Ability (A_{33})	0.055
			Sense of Social Responsibility and Market Integrity (A_{34})	0.055
	Resource Integration Capability (A_4)	0.25	Fund Integration and Utilization Capability (A_{41})	0.065
			Social Relationship Resource Integration and Coordination Capability (A_{42})	0.068
			Technical Resource Integration and Utilization Capability (A_{43})	0.058
			Policy Resource Assessment and Utilization Capability (A_{44})	0.059

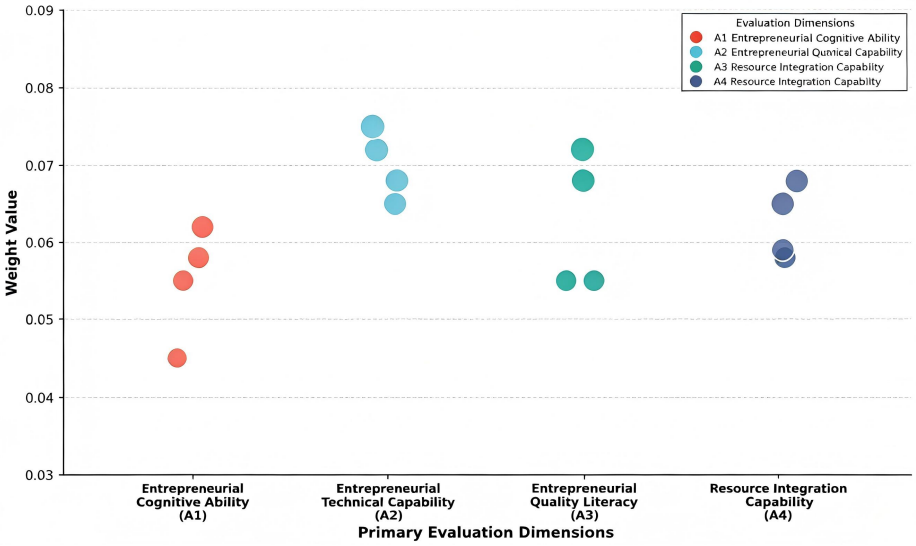

Fig. 2. Comparison of Entrepreneurial Competence Levels Between Students with and without Practical Experience

4.2 Questionnaire Design and Implementation

Based on the established evaluation indicator system, the "Guangzhou Institute of Science and Technology Student Entrepreneurship Competency Survey Questionnaire" was designed. The questionnaire comprised two sections: basic respondent information (gender, grade level, major, participation in innovation and entrepreneurship activities, etc.) and evaluation indicator scoring. The evaluation indicators utilized a 5-point Likert scale corresponding to five rating levels (1=Poor, 2=Fair, 3=Moderate, 4=Good, 5=Excellent), denoted as *V1-V5*.

The survey employed a blended online and offline approach, distributing questionnaires to students from freshman to senior years at Guangzhou Institute of Science and Technology. A total of 800 questionnaires were distributed, with 756 returned. Of these, 723 were valid, yielding a valid response rate of 90.38%. The sample demographics are as follows: Gender: 386 males (53.4%), 337 females (46.6%);By grade level: Freshmen 185 (25.6%), Sophomores 213 (29.5%), Juniors 201 (27.8%), Seniors 124 (17.1%);By major: Engineering majors: 428 (59.2%); Business/Management majors: 215 (29.7%); Other majors: 80 (11.1%); Regarding participation in innovation and entrepreneurship activities: Participants: 326 (45.1%); Non-participants: 397 (54.9%).

4.3 Data Processing and Construction of Fuzzy Evaluation Matrix

First, the valid questionnaire data were organized. The frequency and frequency distribution of each secondary indicator across different evaluation levels were

calculated. The frequency was used as the membership degree r_{ij}, representing the frequency of indicator i at evaluation level *j*. The calculation formula is:

$$r_{ij}=\frac{\textit{The frequency of this grade selection } f_{ij}}{\textit{Total valid questionnaires } N}$$

Where: The sum of the five membership degrees for each secondary indicator equals 1, i.e.

$$\sum_{i=1}^{16}\sum_{j=1}^{5} r_{ij}=1(i=1,2,\cdots,16;\ j=1,2,\cdots,5)\ ;$$

Taking entrepreneurial cognitive ability A_1 as an example, the sum of its five membership degrees (entrepreneurial policy judgment ability A_{11}, industry development analysis ability A_{12}, entrepreneurial risk identification ability A_{13}, and entrepreneurial legal and regulatory mastery ability A_{14}) equals 1. This condition must be satisfied for all secondary indicators across other dimensions.

Second, the membership degree vectors of each calculated secondary indicator are arranged sequentially as rows to form a 16-row, 5-column fuzzy evaluation matrix with dimensions $R_{(16,5)}$. This matrix is then decomposed into R_1-R_4 fuzzy evaluation matrices.

Where: $R = \{R_1,R_2,R_3,R_4\}$ and R_1,R_2,R_3,R_4 represent the fuzzy matrices for entrepreneurial cognitive ability A_1, entrepreneurial technical ability A_2, entrepreneurial quality literacy A_3, and Resource Integration Capability A_4, respectively. R_1, R_2, R_3, R_4 are all 4-row, 5-column fuzzy evaluation matrices.

Rows: Correspond to secondary evaluation indicators (e.g., A_{11}- A_{14}, totaling 4 indicators); Columns: Correspond to fuzzy evaluation grades (Excellent, Good, Moderate, Poor, Bad), totaling 5 grades.

Finally, the permutation results of the fuzzy evaluation matrices R_1,R_2,R_3,R_4 are as follows:

$$\boldsymbol{R_1}=\begin{pmatrix} 0.12 & 0.23 & 0.45 & 0.15 & 0.05 \\ 0.10 & 0.21 & 0.48 & 0.16 & 0.05 \\ 0.25 & 0.42 & 0.13 & 0.05 & 0.05 \\ 0.18 & 0.28 & 0.38 & 0.12 & 0.04 \end{pmatrix}_{4x5}$$

Similarly, we obtain: R_2, R_3, and R_4 .

4.4 Calculation and Analysis of Fuzzy Comprehensive Evaluation Results

Evaluation Results for Secondary Indicators. Multiply the weight vector of each dimension by its corresponding fuzzy evaluation matrix to obtain the fuzzy comprehensive evaluation results for each primary indicator. Taking the entrepreneurial cognition dimension as an example, its weight vector $W_1=[0.058,0.062,0.055,0.045]$. Calculating yields $B_1=W_1\times R_1=[0.13,0.24,0.44,0.14,0.05]$. Based on the maximum membership principle, the evaluation grade for the entrepreneurial cognition dimension is moderate. Similarly, the evaluation results for the other three dimensions are calculated as follows: $B_2= [0.11, 0.20, 0.46, 0.18, 0.05]$ (Entrepreneurial Technical

Competence, Medium); B_3= *[0.08, 0.18, 0.45, 0.22, 0.07]* (Entrepreneurial Quality Literacy, Medium); B_4= *[0.16, 0.26, 0.40, 0.13, 0.05]* (Resource Integration Capability, Medium).

Comprehensive Evaluation Results. Multiplying the weight vector *W=[0.22,0.28,0.25,0.25]* by the evaluation result matrices of each primary indicator yields the comprehensive evaluation results $B=W\times[B_1, B_2, B_3, B_4]$= *[0.12, 0.22, 0.44, 0.17, 0.05]*. Based on the maximum membership principle, the comprehensive evaluation grade for Guangzhou Institute of Science and Technology students' entrepreneurial competency is moderate.

Result Analysis. (1) Evaluation results across dimensions indicate that Guangzhou Institute of Science and Technology students' entrepreneurial competency is moderately developed in all four dimensions, with the following shortcomings: First, relatively weak resource integration capabilities, particularly in capital and technological resource integration, where 26% of membership degrees fall into the "poor" category. This may stem from two causes: First, students lack awareness of external resource channels (e.g., government startup subsidies, angel investments). Second, campus curricula lack systematic training in resource integration. Students interviewed stated, "We know we need funding and technology, but we don't know how to obtain or negotiate them." Second, insufficient risk management and problem-solving skills within entrepreneurial competencies, with only 13% of membership degrees rated "good". This phenomenon correlates with private universities' tendency to prioritize project planning over risk simulation in practical training, leaving students untrained in decision-making within real or simulated high-risk scenarios. Third, legal and regulatory awareness within entrepreneurial cognition is notably weak, with 28% of responses rated as "poor". This reflects inadequate legal modules in general entrepreneurship courses and insufficient collaboration with practical departments like industry and commerce or taxation. Students consequently lack systematic understanding of core regulations.

The scores across the four dimensions reveal a pattern of "three highs and one low" (see Figure 3). Scores for Entrepreneurial Cognition Ability (72 points), Entrepreneurial Technical Capability (71 points), and Entrepreneurial Quality Literacy (70 points) were closely aligned, while Resource Integration Capability scored only 65 points, significantly lower than other dimensions.

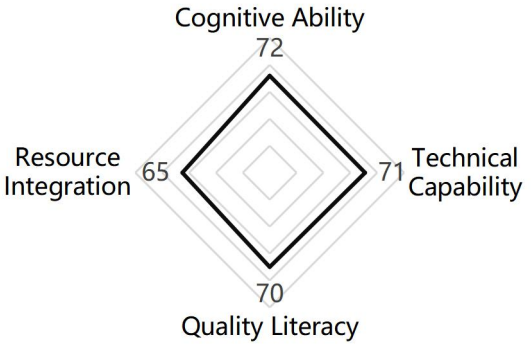

Fig. 3. Radar Chart of Entrepreneurial Competence Dimensions

Note: Scores are derived from the fuzzy evaluation result vectors B1–B4. Values represent converted scores for each dimension based on membership degrees of the "moderate" level.

Although Resource Integration Capability represents an overall weakness, it remains unclear whether this deficiency is universally present across different student groups. Therefore, further analysis was conducted based on whether students participated in innovation and entrepreneurship activities.

(2) To further evaluate the practical effectiveness of innovation and entrepreneurship activities, this study categorized the sample based on the questionnaire item "Have you participated in innovation and entrepreneurship activities?" into a group with practical experience (326 individuals) and a group without practical experience (397 individuals). The entrepreneurial competency assessment results for each group are calculated separately (see Table 2).

Table 2. Comparison of Entrepreneurial Competence Evaluation Results Among Students with Different Practice Participation Levels

Dimension	Practical Experience (N=326)	No Practical Experience (N=397)	Difference
Entrepreneurial Cognitive Ability	Good (0.38)	Moderate (0.46)	+
Entrepreneurial Technical Capability	Good (0.35)	Moderate (0.48)	+
Entrepreneurial Quality Literacy	Good (0.40)	Moderate (0.45)	+
Resource Integration	Moderate (0.42)	Moderate (0.44)	No significant difference
Overall Evaluation	Good (0.35)	Moderate (0.51)	Significant difference

Sample characteristics reveal that students who participated in innovation and entrepreneurship activities scored significantly higher in entrepreneurial competency evaluations ($B' = [0.15, 0.18, 0.35, 0.25, 0.07]$), significantly higher than those who did not participate ($B'' = [0.09, 0.25, 0.51, 0.12, 0.03]$); This indicates that practical components such as project-based learning and competition simulations effectively enhance students' business acumen and execution capabilities, serving as a powerful supplement to classroom instruction. Additionally, engineering students demonstrated slightly higher entrepreneurial skills and resource integration abilities than business and other majors; senior students exhibited superior entrepreneurial cognition and entrepreneurial qualities compared to juniors.

The comparison results show that students with practical experience achieved good levels across all three dimensions—entrepreneurial cognition, technical skills, and character—significantly outperforming non-participants. However, both groups demonstrated only moderate resource integration capabilities, with no significant gap between them. These findings further confirm that existing innovation and entrepreneurship programs effectively cultivate students' business acumen and execution capabilities. Nevertheless, they still exhibit gaps in training the core entrepreneurial skill of resource acquisition and integration, which requires urgent strengthening. This suggests that future practice platform upgrades should prioritize simulating and training core aspects such as funding acquisition and government-enterprise collaboration.

5 Countermeasures

Based on the fuzzy evaluation results and in alignment with the requirements of Guangzhou Institute of Science and Technology's Implementation Plan for High-Quality Development of Innovation and Entrepreneurship Education, targeted cultivation pathways are proposed across four dimensions: curriculum system optimization, practical platform upgrades, faculty development, and improvement of support mechanisms.

5.1 Optimize the Curriculum System to Strengthen Foundational Entrepreneurial Knowledge

Establish a three-tier curriculum system comprising "general education + specialized courses + practical training": At the general education level, incorporate "Fundamentals of University Student Innovation and Entrepreneurship" as a required course. Increase instructional emphasis on entrepreneurship policies, laws and regulations, and risk prevention. Invite government officials, lawyers, and other experts to deliver specialized lectures to enhance students' entrepreneurial cognition. At the specialized education level, deepen the integration of specialization and entrepreneurship. Each discipline should offer elective courses with an entrepreneurial focus tailored to its characteristics, such as "Practical Technology Entrepreneurship" for engineering majors and "Business Model Innovation" for

economics and management majors. This approach will uncover entrepreneurial elements within specialized curricula, enhancing their relevance and practicality. At the practical training level, courses such as business plan writing, market research, and simulated entrepreneurship will be offered. Teaching methods like case studies and project-driven approaches will be employed to enhance students' practical entrepreneurial skills.

5.2 Upgrading Practical Platforms to Elevate Entrepreneurial Skills

Enhance on-campus practical platforms: Strengthen the development of innovation and entrepreneurship simulation labs, startup parks, and incubation bases. Equip these spaces with professional simulation software to provide students with realistic entrepreneurial practice environments. Promote the opening of teaching platforms like training centers and specialized labs for students, supporting their engagement in scientific research training and invention activities. Establish student associations such as Innovation and Entrepreneurship Societies and Startup Clubs, regularly organizing events like entrepreneurship salons and boot camps to foster a vibrant entrepreneurial atmosphere. Deepen university-industry collaboration and expand off-campus practice bases: Leverage social resources to establish deep cooperative relationships with science parks, high-tech industrial development zones, and industry-leading enterprises, jointly building off-campus innovation and entrepreneurship practice bases.

5.3 Strengthen Faculty Development and Enhance Entrepreneurship Guidance Capabilities

Build a faculty team combining full-time and part-time members: Recruit full-time faculty with rich entrepreneurial experience and strong theoretical expertise, while clarifying innovation and entrepreneurship education responsibilities for all faculty. Establish specialized training programs for faculty innovation and entrepreneurship, regularly organizing participation in entrepreneurship education seminars and corporate internships to enhance teaching and mentoring capabilities. Actively recruit distinguished external talents, including renowned scientists, entrepreneurs, successful innovators, and venture capitalists, as adjunct faculty and innovation/entrepreneurship mentors to provide comprehensive guidance services. Refine faculty incentive mechanisms by incorporating innovation/entrepreneurship education performance into faculty title evaluations, promotion decisions, and performance assessments. Encourage active participation in innovation/entrepreneurship teaching, student competition coaching, and startup incubation projects.

5.4 Refine Support Mechanisms and Optimize the Entrepreneurial Ecosystem

Refine credit recognition and conversion systems: In accordance with the "Credit Recognition and Conversion Management Measures", further optimize the

accumulation and conversion system for innovation and entrepreneurship credits. Permit students to earn credits through academic competitions, scientific research, inventions, and entrepreneurial practice. Implement flexible academic systems allowing leave of absence for entrepreneurship to stimulate student initiative. Establish an entrepreneurship fund to provide financial support: In accordance with national, provincial, and municipal regulations, establish an entrepreneurship fund to offer financial support, consulting services, and technology transfer assistance for technological innovation projects and start-up enterprises. Develop a comprehensive guidance service system: Establish a "full-process, personalized" entrepreneurship guidance service system, providing continuous support, comprehensive guidance, and one-stop services for students with entrepreneurial aspirations and potential.

6 Conclusions and Outlook

6.1 Research Findings

Using Guangzhou Institute of Science and Technology as a case study, this paper constructs a fuzzy evaluation system for entrepreneurial competence among private university students. This system includes four primary evaluation dimensions: entrepreneurial cognitive ability, entrepreneurial technical ability, entrepreneurial character and literacy, and Resource Integration Capability, comprising 16 secondary evaluation indicators. Empirical research yields the following conclusions:

First, the overall entrepreneurial competency of Guangzhou Institute of Science and Technology students is at a moderate level, with room for improvement across all four dimensions. Second, resource integration capability, risk response and problem-solving ability, and awareness of entrepreneurial laws and regulations represent the primary shortcomings in students' entrepreneurial competence. Third, innovation and entrepreneurship practice activities significantly enhance students' entrepreneurial competence, with variations observed across gender, grade level, and major.

Based on these findings, the four cultivation pathways proposed in this paper: optimizing the curriculum system, upgrading practical platforms, strengthening faculty development, and improving support mechanisms are crucial for enhancing the entrepreneurial competence of Guangzhou Institute of Science and Technology students.

6.2 Research Outlook

While this study has achieved certain results, limitations remain: First, the sample was restricted to Guangzhou Institute of Science and Technology, necessitating further validation of the findings' generalizability. Second, indicator weighting in the fuzzy evaluation model primarily relied on expert subjective judgment; future refinement could incorporate objective methods like entropy weighting. Third, the implementation effectiveness of the cultivation pathways has yet to undergo follow-up assessment. Future research should expand the sample scope to include multiple private universities in Guangdong Province for comparative studies; further refine the

evaluation model to enhance the objectivity and precision of assessment outcomes; and conduct long-term tracking evaluations of the implementation effects of cultivation pathways to continuously improve cultivation strategies. Concurrently, integrating emerging technologies such as the digital economy and artificial intelligence could explore new connotations, dimensions, and cultivation models for entrepreneurial competence among students in private universities in the new era, providing stronger support for advancing the high-quality development of innovation and entrepreneurship education in private institutions.

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