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The evaluation of college students' innovation and entrepreneurship ability based on nonlinear model

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Abstract

Under the background of 'mass entrepreneurship and innovation', Chinese colleges and universities have strengthened students' entrepreneurial and innovative abilities. The article first analyses the reasons why applied universities should strengthen innovation and entrepreneurship education. On this basis, the evaluation index system of students' innovation and entrepreneurship ability is constructed. The thesis uses the nonlinear structural model to complete the index weight setting. Finally, the paper verifies the effectiveness of the combined evaluation model through the data on innovation and entrepreneurship of college students in an university where applied. At the same time, the article proposes measures for optimising the ecological environment of innovation and entrepreneurship education for colleges and universities.

Keywords: university innovation and entrepreneurship education, nonlinear model, ecological environment, evaluation system**AMS 2010 codes:** 70K75

1 Introduction

Innovative talents are an essential resource for realising the goals of the 'National Innovation-Driven Development Strategy Outline'. 'Innovation-driven is essentially talent-driven' profoundly reveals the breakthrough and focus of the innovation-driven development strategy. To implement the innovation-driven strategy and build an innovative country, we must accelerate the cultivation of innovative talents. This has also become an important task of college education reform. College students are a new force in implementing innovation-driven development strategies and promoting mass entrepreneurship and innovation [1]. Students must study hard and master

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more knowledge and devote themselves to innovation and entrepreneurship to improve their practical ability. However, entrepreneurship research at home and abroad has not paid particular attention to the entrepreneurial group of college students. Under the background of ‘innovation and entrepreneurship’ and the policy of ‘promoting employment by entrepreneurship’, entrepreneurship education for college students has begun to be fully implemented in higher education institutions in China [2]. Cultivating college students’ entrepreneurial ability is an essential goal for universities to promote entrepreneurship education. The scientific evaluation of college students’ entrepreneurial ability is a crucial way to measure the quality of university entrepreneurship teaching. Figure 1 shows the importance of innovation and entrepreneurship among college students.

Fig. 1 The importance of innovation and entrepreneurship among college students.

The research on the entrepreneurial ability of college students begins with a discussion on the characteristics of entrepreneurial ability. Some scholars put forward the concept of ‘entrepreneurial ability’ for the first time and defined it as ‘the ability to discover, predict and use opportunities’. Since then, different researchers have discussed the connotation of entrepreneurial ability from their respective theoretical perspectives. The content roughly includes the following perspectives: (1) the resource perspective believes that entrepreneurial ability is a variety of tangible or intangible resources that entrepreneurs master in entrepreneurial activities, including funds, Equipment, information, technology and reputation. This is the resource base to support the smooth development of entrepreneurial activities [3]; (2) the process perspective emphasises that entrepreneurial ability is using and integrating various resources by entrepreneurs and the course of action for creative development of market opportunities. Entrepreneurship capabilities from a process perspective include the discovery and refinement of entrepreneurial opportunities and the deployment and integration of resources to develop and utilise entrepreneurial opportunities; and (3) the opportunity perspective believes that the discovery of entrepreneurial opportunities is an essential foundation for entrepreneurship. Perceiving entrepreneurial opportunities is a crucial prerequisite for using and integrating resources to create potential profit margins. Therefore, successfully gaining insight and developing market opportunities is an essential feature of entrepreneurs’ ability.

Existing research regards the entrepreneurial ability of college students as a comprehensive ability or the ability of individuals to create new occupations or open new jobs independently, and some think it is all the intelligence that can create socially valuable products and services, which is the sum of factors and non-intellectual factors. The current analysis of college students’ entrepreneurial abilities primarily draws on and inherits the viewpoints and methods in the field of entrepreneurial management research, and has not effectively identified and distinguished the essential differences between mature entrepreneurs and college students in the entrepreneurial process, and also not thoroughly examined the knowledge structure, knowledge structure and differences in thinking patterns. Based on this research background, this article believes that the ecological environment of university innovation and entrepreneurship education can be characterised with three levels: entrepreneurial system environment, resource allocation environment and entrepreneurial formation results [4].

2 Construction of the evaluation index system

Based on the three criterion levels of the entrepreneurial system environment, system resource allocation and entrepreneurial formation results, the author constructed a university innovation and entrepreneurship education

Table 1 Ecological environment evaluation index system and weight coefficient of university innovation and entrepreneurship education.

Criterion layer	First-level index	Secondary indicators	Combination weight
Entrepreneurship system environment	On-campus practice platform	Number of undergraduate entrepreneurship incubation bases B1 Number of business guidance agencies B2 Investment in Innovation and Entrepreneurship Lab B3	0.0289 0.0318 0.0401
	Off-campus expansion platform	Number of off-campus practice bases B4 Number of off-campus entrepreneurial practice tutors B5 Experts come to school to guide entrepreneurship B6	0.0354 0.0326 0.0317
System resource allocation	Environment system	Number of visits to information service platform B7 Student Innovation and Entrepreneurship Credit Score B8	0.0374 0.0309
	Faculty construction environment	Number of full-time teachers for innovation and entrepreneurship B9 Number of teachers with practical experience in entrepreneurship B10 The proportion of teachers in higher vocational colleges B11 Number of lessons taught by external entrepreneurial tutors B12	0.0289 0.0355 0.0279 0.0355
	Curriculum construction environment	Number of courses offered for innovation and entrepreneurship B13 Entrepreneurship practice training courses offer number B14 Number of Open Online Courses for Innovation and Entrepreneurship B15 Number of interdisciplinary courses B16	0.0317 0.0327 0.0336 0.0279
	Financial support environment	Per capita expenditure on innovation and entrepreneurship B17 Funding B18 for innovation and entrepreneurship projects Per capita capital support for self-employment B19 The number of social funds introduced B20	0.0308 0.0373 0.0354 0.0411
Entrepreneurship results	Students' sense of innovation and entrepreneurship	Excellent grades in innovation and entrepreneurship courses B21 Number of innovative and entrepreneurial practice teams B22 Per capita participation in innovation and entrepreneurship competitions B23 The number of innovative and entrepreneurial projects declared per capita B24	0.0271 0.0336 0.0346 0.0346
	Student innovation and entrepreneurship	Innovative and entrepreneurial achievements to obtain investment of B25 Average annual entrepreneurial rate B26 The success rate of innovation and entrepreneurship achievement transformation B27 Number of scientific research papers on innovation and entrepreneurship B28 Award rate of innovation and entrepreneurship competition B29 Number of patents obtained for innovation and entrepreneurship achievements B30	0.0383 0.0382 0.0335 0.0335 0.0336 0.0261

Fig. 2 Emerging engineering education innovation and entrepreneurship practice platform evaluation and improvement system.

Fig. 3 Innovation and entrepreneurship platform for college students.

eco-environment evaluation index system containing eight first-level indicators and 30 second-level indicators (Table 1). Therefore, we can collect the original data of the evaluation object based on 30 evaluation indicators to complete the judgement of the advantages and disadvantages of the ecological environment of the innovation

and entrepreneurship education of the evaluation object. However, the types of original data are often inconsistent and have different dimensions, which have an essential impact on the accuracy of the evaluation results. Therefore, the original data needs to be preprocessed first. Figure 2 shows the innovation and entrepreneurship platform for college students [5].

2.1 Data preprocessing

2.1.1 Consistency of indicator types

The unification of indicator types means that different indicators are treated as the same type of indicators. There are four main types of research indicators based on scholarly research, namely 'maximised' indicators (the more significant the indicator value is, the better) and the 'tiny' indicator (the smaller the indicator value is, the better). Different types of indicators represent the values of different preferences [6]. Therefore, the index type must be uniformised before the evaluation value of the evaluating object can be measured. For 'minimal' indicators, we can take the standard method of indicators for 'minimal' indicators to transform them into 'maximised' indicators for 'minimal' indicators.

2.1.2 Dimensionless processing of indicators

Each indicator has its dimension and magnitude. However, they are incommensurable and cannot complete the calculation of the comprehensive index. Therefore, when calculating, we must first make the indicator dimensionless [7]. The dimensionless index is a method to eliminate the influence of the original index dimension and magnitude through mathematical transformation. There are many ways to deal with dimensionlessness. This research adopts the 'minimum and maximum standardisation method' widely used by scholars.

$$z_{ij} = \frac{p_{ij} - \min\{p_{ij}\}}{\max\{p_{ij}\} - \min\{p_{ij}\}} \quad (1)$$

In the above formula z_{ij} is the evaluation index data after the index dimensionless processing. p_{ij} represents the data after the index type is unified. $\{p_{ij}\}$ and $\min\{p_{ij}\}$ respectively represent the maximum value and the minimum value of the data after the j index unification processing.

2.2 Evaluation method based on group G2 method

This research introduces the group G2 method as an evaluation method of the ecological environment of university innovation and entrepreneurship education. This method is suitable for the problem to be solved in this research and it is found to be a scientific and reasonable method after careful consideration of various factors. This ultimately ensures the accuracy and scientificity of the research results.

2.2.1 Principles of Group G2 Method

The group G2 method is developed based on the single G2 method. The main idea of the single G2 method is to invite experts to compare and judge the same sorting problem under a particular target [8]. Finally, the subjective experience of experts is combined to obtain a more accurate weighing result.

We first invite an expert to establish an order relationship for m evaluation indicators $\{x_1, x_2, \dots, x_m\}$. That is, select the least important one and only one index from the evaluation index set and record it as x_m^* . Then, in the remaining evaluation index set, ask the experts to select the least important one and mark it as x_{m-1}^* . By analogy, we mark the remaining evaluation index as x_1^* to determine the order relationship of the evaluation index set, which we denote as $x_1^* > x_2^* \dots x_m^*$. Then, again invite experts to make a rational judgement on the importance index r_i of a criterion (or target) based on the relevant information on the evaluation index x_i^* and the least essential evaluation index x_m^* , that is, let: $r_i = a_j, i = 1, 2, \dots, m-2, m-1$. Among them, we take the assignment of $a_m = 1, r_i = 1$, which shows that both the index x_i^* and the index x_m^* have the same importance. Note that $r_i = 1, 2$ indicates that the index x_i^* is slightly more critical than the index x_m^* ; $r_i = 1, 4$ shows that the index x_i^* is more critical than the index x_m^* ; $r_i = 1, 6$ shows that the index x_i^* is more important than the index x_m^* ;

and $r_i = 1, 8$ shows that the index x_i^* is essential than the index x_m^* . Finally, according to the rational assignment of r_i given by experts, the weight coefficient of the evaluation index x_i^* plus i is obtained [9]. The calculation formula is:

$$\omega_i = a_i / \sum_{i=1}^m a_i, i = 1, 2, \dots, m-1 \quad (2)$$

After making a one-to-one correspondence between the weight coefficient of x_i^* and x_i , we finally obtain the weight coefficient of the single G2 method of the evaluation index set $\{x_1, x_2, \dots, x_m\}$. To compensate the lack of experience and knowledge of a single expert and the interference of personal factors in giving the weight coefficient of the evaluation index more objectively and accurately, we introduce the group G2 method. Based on a single G2 method, we can simultaneously hire L (two or more) experts to judge the order relationship and rationally assign importance to the evaluation indicators [10]. According to the steps of the single G2 method, the weight coefficients of each index are calculated. Then weight coefficients of each index are combined to obtain an ideal weight coefficient. However, there are two situations in which experts have consistent and inconsistent views on the judgement of the index relationship and these two situations should be dealt with.

Suppose that the judgements of L experts on the order relationship in the evaluation index set $\{x_1, x_2, \dots, x_m\}$ are entirely consistent and recorded as $x_1^* > x_2^* \dots x_m^*$. Assume that the ratio of the importance of a specific expert q to r_{km} is assigned as $a_{q1}, a_{q2}, \dots, a_{q(m-1)}, q = 1, 2, \dots, L$ is in order. Calculate the ω_{qk} obtained under the judgement of each expert according to the calculation formula. Finally, we take the arithmetic average of the L group weight coefficients obtained by the L experts to obtain the combined weight coefficient. The calculation formula is as follows:

$$\omega_k = \sum_{q=1}^L \omega_{qk} / L, k = 1, 2, \dots, m \quad (3)$$

The second one is the inconsistent judgement of the order relationship because L experts from the same field have roughly the same qualitative judgements on the same issue. Therefore, in this case, the qualitative judgements of some experts are consistent, while the qualitative judgements of other experts are inconsistent. Suppose that the ordering relationship given by P experts is consistent and denoted as $x_1^* > x_2^* \dots x_m^*$. At this time, the corresponding weights of the indicators can be calculated as $\omega_1^*, \omega_2^*, \dots, \omega_m^*$ according to the sequence mentioned in the above relationship. In addition, suppose that the judgement of the order relationship given by the $L-p$ experts is inconsistent with the above order relationship. The least essential index is different. We set the order relations given by expert k among $L-p$ experts as $x_{k1}^* > x_{k2}^* \dots x_{km}^*, k = 1, 2, \dots, L-p$, respectively. We set the ratio of the importance of expert k to indicators x_{ki}^* and x_{km}^* as $r_{ki} (k = 1, 2, \dots, L-p; i = m, m-1, \dots, 2)$. We then calculate the weight coefficient under the expert k -order relationship and rational assignment according to formula (4) and record it as ω_{ki} . Finally, the weights obtained by $L-p$ experts take the arithmetic average as the result of 'comprehensive weight' and mark it as ω_i^{**} :

$$\omega_i^{**} = \frac{1}{L-p} \sum_{k=1}^{L-p} \omega_{ki}, i = 1, 2, \dots, m \quad (4)$$

After normalising ω_i^{**} , we combine it with the weight ω_i^* obtained by P experts. Finally, the weight coefficient ω_i of each evaluation index is obtained:

$$\omega_i = a\omega_i^* + b\omega_i^{**}, i = 1, 2, \dots, m \quad (5)$$

Among them, $a > 0, b > 0$ and $a + b = 1$ and we take $a = p/L, b = ((L-p)/L)$.

2.2.2 Determination of coefficient

In our study, five experts were invited and denoted as A1, A2, A3, A4 and A5, and two of them came from the government education department. They are policymakers and supervisors, and they are familiar with the specific practical work of college innovation and entrepreneurship education. The other three experts have

come from colleges and universities [11]. Five experts independently judged the order relationship and assigned importance to the 30 evaluation indicators in Table 1. According to the above steps, we assign values according to five experts' order relationship and importance. Next, apply formulas (2) and (3) to obtain the absolute weight coefficients of the five groups of evaluation indicators, and then substitute weight coefficients of the five groups in formula (5) to obtain the final combined weight coefficient.

2.3 Ecological environment evaluation model of university innovation and entrepreneurship education

The ecological environment evaluation model of university innovation and entrepreneurship education is suitable for the nonlinear weighted evaluation model. We write it down as the following formula:

$$y_i = \prod_{j=1}^{30} z_{ij}^{\omega_j} \quad (6)$$

In the above formula y_i is the ecological environment of innovation and entrepreneurship education for the i -th university. z_{ij} is the evaluation value of the original index data x_{ij} and ω_j is the weight coefficient corresponding to the j evaluation index.

3 Related suggestions

3.1 Entrepreneurship education scenarios are compounded

The scenario shaping of entrepreneurial education is intended to form a positive entrepreneurial education atmosphere. This method absorbs all participants into the entrepreneurship education system, which helps to promote the development of entrepreneurship education actively. Entrepreneurship education should highlight the compounding of educational scenarios. Entrepreneurship education is not just for cultivating college student as entrepreneurs. The structural model of the entrepreneurial ability of college students shows that entrepreneurial ability is a multi-dimensional concept and it does not simply involve specific skills such as starting and man-

Fig. 4 Emerging engineering education innovation and entrepreneurship practice platform evaluation and improvement system.

aging enterprises [12]. The entrepreneurial capability structure model also involves comprehensive skills such as team management and resource integration. Among them, innovative spirit, sense of responsibility and entrepreneurial knowledge support the forces behind entrepreneurial ability. Only by establishing the ideological understanding of ‘by imparting knowledge, shaping the spirit, and supporting the cultivation of entrepreneurial ability’ can we genuinely attract teachers and students, and other key participants to integrate into the university’s entrepreneurial education actively. Figure 4 shows the evaluation and improvement system of the emerging engineering education innovation and entrepreneurship practice platform.

3.2 Systematisation of entrepreneurship education input

To realise the practical cultivation of the entrepreneurial ability of college students, the input of entrepreneurship education is not limited to classroom teaching and practical guidance but a complex system composed of entrepreneurship teachers, entrepreneurship courses and entrepreneurship training. In addition, the system includes knowledge-led ability training for team management and program configuration and includes opportunity insight and resource integration ability development.

3.2.1 Systematisation of teachers of entrepreneurship education in colleges and universities

On the one hand, the teaching staff of entrepreneurship should achieve crossover and diversity. Entrepreneurship management-related courses mainly involve economic management, even law, and other aspects of knowledge. It is challenging for a single teacher to master relevant field knowledge very professionally. Therefore, we need professional teachers from different professional fields, such as financial management, marketing, human resource management, etc., to build a systematic education team of teachers. On the other hand, in addition to academic teachers who have mastered theoretical knowledge, entrepreneurs or serial entrepreneurs with rich entrepreneurial experience should also be invited to provide special lectures and exchanges, especially for practice and training guidance in industry experience and team management in project financing. Only a team of teachers with comprehensive professional knowledge and different development backgrounds can provide a faculty foundation for cultivating comprehensive college students’ entrepreneurial ability.

3.2.2 Systematisation of entrepreneurship education curriculum in universities

Entrepreneurship courses for college students involve knowledge systems in various aspects such as entrepreneurial foundation, innovative thinking and entrepreneurial leadership. Colleges and universities must keep up with the pace of knowledge updates in majors and curriculum following the new needs of the era of ‘mass entrepreneurship and innovation’. However, most colleges and universities currently only offer ‘Undergraduate Entrepreneurship Fundamentals’ as a course of innovation and entrepreneurship modules and is mainly a elective course. The lack of entrepreneurship education curriculum construction is another crucial factor restricting the cultivation of college students’ entrepreneurial ability. Due to the setting of the professional curriculum system and the limit of total credits, students generally lack the study and awareness related to training of economic management and to knowledge in humanities and social sciences. For college students’ entrepreneurial ability, opportunity insight, team management and other competency dimensions require knowledge and skills education outside of the discipline. Therefore, in addition to the systematic innovation and entrepreneurship courses with the theme of ‘entrepreneurship’ for college students, courses related to human geography, interpersonal communication, team management and financial education should also be offered.

3.2.3 Systematisation of entrepreneurship education training in colleges and universities

The system develops skills through training methods such as sand table simulation and entrepreneurial games. The second is to set up a physical entrepreneurial training base to conduct exercises such as simulation of the establishment process of entrepreneurial enterprises, display of entrepreneurial projects and training of entrepreneurial investment and financing negotiations. The third is the combination of inside and outside the school. Entrepreneurship training is based not only on the use of school-related resources but also on the school to encourage students to participate in entrepreneurial competitions, social research, visiting ‘crowd in-

novation space' and communicate with entrepreneurs. The students should watch and participate in various entrepreneurial project road-shows and fund matching activities held by social organisations. Let students 'learn by doing' can effectively enhance college students' social vision and operational skills in entrepreneurship.

3.3 Teamisation of the entrepreneurship education process

Entrepreneurship education is not limited to a few hours in the classroom but a continuous training process that runs through the classroom. In this process, entrepreneurial teachers and trainees are the main participants and main actors.

3.3.1 Entrepreneurship instructor itemisation

Entrepreneurship guidance has both academic and practical requirements. This requires the instructor to have profound entrepreneurial theoretical research and rich experience in entrepreneurial practice. Unfortunately, at present, there are very few such entrepreneurial instructors in Chinese universities. To make up for this shortcoming, it is necessary to employ the new instructors with necessary experience. To cultivate college students' entrepreneurial ability, the itemisation of entrepreneurial instructors includes two aspects: one is the matching of instructors of technical knowledge and entrepreneurial knowledge. The essence of innovation and entrepreneurship is to use emerging technologies to meet real society's needs to achieve the success of entrepreneurial activities. Therefore, college students must cultivate the ability to effectively match 'customer pain points' and 'market gaps' with technical resource conditions, which must be completed under the cooperation of technical instructors and entrepreneurial instructors. The second is the matching of instructors of theoretical knowledge and practical knowledge. College students' learning and mastering the theoretical knowledge of entrepreneurship are the critical foundation for scientific entrepreneurship and a critical way to make up for their lack of experience. Therefore, it is necessary to realise the itemisation of knowledge teachers and experienced teachers in entrepreneurship education.

3.3.2 Entrepreneurship learning process itemisation

Entrepreneurship learning in universities is realised in the form of individual students participating in the classroom and practice. However, entrepreneurial activities are a kind of team project that is difficult to complete with high quality only by one person. Therefore, the learning team should be built at the beginning of the student's participation in the entrepreneurial learning process. First, complete all learning and training subjects through teamwork. The second is that students with different professional backgrounds and knowledge structures in the learning team can better learn and communicate with each other to achieve growth and progress in the team. Third, as a team member, especially a team coordinator, it is necessary to coordinate members with different personalities and personality characteristics through effective communication and goal management. This can exercise and accumulate team management skills and experience.

3.4 Projectisation of entrepreneurship education achievements

Most of the college students' professional learning achievements are examinations and scores must reflect them. Entrepreneurship education is different from the installation and learning of general professional knowledge and so its assessment method should also be different from traditional professional education. Projectisation is a crucial way to display the results of entrepreneurial education, including evaluating the learning process and the quality of the results.

3.4.1 Entrepreneurship education process assessment projectisation

Entrepreneurship education is not a 'sprint' in pursuit of speed but a 'marathon' that values the process. Since it is a 'marathon' of educational activity, some 'timing points' should be set during this long process for process control and assessment. The 'timing point' of the entrepreneurial education process can be either a homework test in the form of an analysis report or a psychological reflection with cognitive action as the main body. The analysis report includes written materials such as market analysis report, business model canvas,

financing plan, business charter and business plan completed by the team as a unit. Cognitive actions include team activities such as visiting business incubators and crowd-creation spaces and interviewing entrepreneurs. Cognitive action needs to be completed as a team but presented in the form of individual summaries.

3.4.2 Entrepreneurship education quality assessment projectisation

Educational assessment methods have a decisive guiding role in teaching objectives and the development of teaching activities. The evaluation of the quality of entrepreneurial education results does not lie in the scores of students in the examination papers but a comprehensive reflection of the entrepreneurial knowledge and skills that students have mastered through systematic entrepreneurial learning. Project-based assessment methods can reflect entrepreneurship education's essential characteristics and help cultivate college students' entrepreneurial ability. The business plan completed by the student team should be an important indicator of the quality of entrepreneurship education. At the same time, students participate in various national and regional entrepreneurship competitions, such as the National College Student E-commerce 'Innovation, Creativity, and Entrepreneurship' Challenge, the 'Creative Youth' National College Student Entrepreneurship Competition, and the China 'Internet +' College Student Innovation and Entrepreneurship Competition, etc. It can be an important way to assess the quality of entrepreneurship education, and can also provide meaningful guidance for the design and implementation of entrepreneurship education.

4 Conclusion

The thesis uses the combined weight model to obtain college students' innovation and entrepreneurship index weights. The effectiveness of the combined evaluation model is verified by the data of college students' innovation and entrepreneurship in an application-oriented university. Thus, the research results can provide a new idea for evaluating college students' innovation and entrepreneurship ability in the application-oriented university.

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