# Research on the Innovation and Entrepreneurship of College Students' Education Evaluation based on Analytic Hierarchy Process

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***Abstract***

*Cultivation of innovative talents has already been the focus of education research, in this paper; we research the innovation and entrepreneurship education system, constructing the index system of innovation and entrepreneurship education for college students. Using the analytic hierarchy process and gray theory, we studied the quantitative evaluation of innovation and entrepreneurship education of college students. Taking North China University of science and engineering as an example, we put forward a set of countermeasures and suggestions on the cultivation of innovation and entrepreneurship education for college students.*

***Keywords:*** *College student, Innovation and Entrepreneurship, Evaluation index system, Analytic hierarchy process, Grey Theory*

## 1. Introduction

China's society is undergoing an economic transformation; the number of college students continues to grow, facing the problem of employment. How to resolve the structural contradictions in the economic transformation of employment has become an important issue in the current society [1]. To cultivate innovative quality, innovative ability and innovative personality for the purpose of innovation and entrepreneurship education, once again become the focus of education research. The general goal of higher education reform is to establish and improve the quality of classroom teaching, independent learning, combined with practice, guidance and culture to create a higher education system [2]. The quality of talents training is improved significantly, and the students' innovation spirit, entrepreneurial consciousness and innovation ability are significantly enhanced. The innovation and entrepreneurship education will become a breakthrough to deepen the comprehensive reform of higher education. College students are one of the most innovative and entrepreneurial potential. How colleges and universities rely on the development of innovation and entrepreneurship education, tap the potential of students, and promote the students to adapt to the social and economic development, is the current urgent need to consider the practical issues.

The domestic and foreign scholars have carried on many angles to the university student innovation and entrepreneurship education. The research mainly focuses on the following aspects: the combination of various institutions and their own characteristics, innovation and entrepreneurship education, innovation and entrepreneurship education platform, innovation and entrepreneurship education and college specific major categories, design and adopt a variety of teaching reform to enhance the quality of innovation and entrepreneurship. At home and abroad, the research on the evaluation index system of innovation and entrepreneurship education is relatively small, and the design of the index is lack of comprehensive. In addition, the construction of the evaluation index system of innovation and entrepreneurship education can not only improve the innovation and

entrepreneurship education theory system, but also can be used as the main basis for evaluating the effect of innovation and entrepreneurship education. Based on the above background, this paper draws on the relevant research in the field of domestic and foreign scholars to establish a comprehensive evaluation index system of innovation and entrepreneurship education, the use of AHP and gray theory to quantify the evaluation of innovation and entrepreneurship education for college students.

## 2. Literature review

### 2.1. The Connotation of Innovation and Entrepreneurship Education

In recent years, domestic scholars have carried out many studies on innovation education and entrepreneurship education from various fields, but the concept of innovation and entrepreneurship education has a high degree of ambiguity. At the end of twentieth Century, the International Conference on entrepreneurship and innovation in Tokyo from a broad perspective, the definition of entrepreneurship innovation education as: training the most creative personality, including the pioneering spirit, adventure spirit, entrepreneurial ability, independent working ability and technology, social and management skills training. Xiaoling (2013) believes that innovation and entrepreneurship education focuses on improve the comprehensive quality of talents [3], aimed at training students' innovative spirit and innovative consciousness, to better adapt to the social development and changes, it is a new educational idea and talent training mode. Yanfei (2013) point out that innovation and entrepreneurship education is to foster the development of a new era of innovation and entrepreneurship, innovation and entrepreneurship, innovation and entrepreneurship and innovation and entrepreneurship personality of high quality personnel as the goal [4]. Wang (2015) through the analysis of the connotation of innovation and entrepreneurship education, there are three kinds of understanding [6]: first, the innovation and entrepreneurship education is equivalent to innovation education; the two is the innovation and entrepreneurship education is equivalent to entrepreneurship education; the three is the innovation and entrepreneurship education as a combination of innovative education and entrepreneurship education. From the above literature on innovation and entrepreneurship education, we can see that innovation and entrepreneurship education is to cultivate the basic quality of the talents as the goal, to cultivate the students' innovative, creative and practical characteristics [7-8].

### 2.2. Elements of Innovation and Entrepreneurship Education

Innovation and entrepreneurship education is a complex education work, many factors are important to the work of this work, this article on the basis of the connotation of innovation and entrepreneurship education, build the evaluation index system of College Students' innovation and entrepreneurship education, which mainly includes four indicators: innovation and entrepreneurship education, innovation and Entrepreneurship Education, innovation and entrepreneurship education.

1) *Resource Allocation Index:* the resources for the realization of innovation and entrepreneurship education, including human, material and financial resources, but also contains some of the social costs cannot be quantified and qualitative, such as teachers, financial investment, organizational support, etc.

2) *Education Process Indicators:* to reflect the quality of innovation and entrepreneurship education in the process of monitoring and implementation

of the activities of the implementation of indicators [9]. Such as innovation and entrepreneurship projects, innovation and entrepreneurship education courses, *etc*.

3) **Education Outcome Indicators:** the quality of the results or the ability to improve the performance of innovation and entrepreneurship education indicators[10], including direct or indirect benefit of the output. Such indicators have the ability to enhance the effect of innovation and entrepreneurship education, innovation and entrepreneurship education extension activities, *etc*.

4) **Education Benefit Indicators:** The benefit index of innovation and entrepreneurship education is the realization of the expected goal of innovation and entrepreneurship education, such as economic benefit and social benefit.

## 3. Research Design and Main Method

### 3.1. The Principle of Index System

Scientific principle: the construction of the index system should be based on the theoretical basis, to be able to objectively and accurately reflect the essence and connotation of innovation and entrepreneurship education of College students.

Systematic principle: there is a certain logical relationship between the various indicators, from the organization, education environment, education, education, education teachers, students, education and other aspects of the formation of an inseparable evaluation index system.

Typical principles: the selection of indicators should be representative and typical, the construction of indicators should be able to accurately reflect the characteristics of various aspects of innovation and entrepreneurship education of College students.

Quantifiable principle: the design of the requirements of the management research methodology should be feasible, the index selection is simple, easy to collect, the calculation method and calculation method must be consistent with the reality. In addition, it is also necessary to consider the possibility of quantitative analysis.

### 3.2. The Design of the System

At present, the research on innovation and entrepreneurship education has become the focus of attention of scholars at home and abroad. However, there are not many studies on the comprehensive evaluation of College Students' innovation and entrepreneurship education, and the lack of analysis and judgment of College Students' innovation and entrepreneurship education from the perspective of quantitative and qualitative analysis. This paper is based on the research results of domestic and foreign scholars on innovation and entrepreneurship education, and the relevant policies of the state and combined with the understanding of the concept of innovation and entrepreneurship education, based on the principle of innovation and entrepreneurship education index system, build a comprehensive evaluation index system of innovation and Entrepreneurship Education. The index system consists of three levels. The first layer of the target layer is the innovation and entrepreneurship education for college students. The second layers are composed of 4 aspects: innovation and entrepreneurship education, innovation and entrepreneurship education, innovation and entrepreneurship education. The third layer is a set of evaluation criteria. As shown in Table 1.

**Table 1. The Evaluation Index of Innovation and Entrepreneurship Education for College Students**

| First-Level indicators $C_i$ | Second-Level indicators | Third-Level indicators |
|---|---|---|
| Education resource allocation $C_1$ | Teacher investment $C_{11}$ | Innovation and entrepreneurship education teachers |
| | | Senior Title Innovation and entrepreneurship education teacher |
| | | High degree of innovation and entrepreneurship education teachers |
| | Fund investment $C_{12}$ | Financial appropriation |
| | | University grant number |
| | | Self financing number |
| | Organization guarantee $C_{13}$ | Policies and preferential measures |
| | | Management organization and system |
| | | Advisory service center number |
| | | school and enterprise cooperation |
| Education process $C_2$ | courses $C_{21}$ | open courses number |
| | | lecture & salon |
| | Project $C_{22}$ | number of projects |
| | | College Students' Participation |
| | Practical platform $C_{23}$ | business parks |
| Education results $C_3$ | Quality improvement $C_{31}$ | Cognitive situation |
| | | entrepreneurial spirit |
| | | Personality psychological characteristics |
| | | Student participation |
| | | Research project |
| | Entrepreneurial effect $C_{32}$ | Enterprise number |
| | | Cumulative number of graduates |
| Education benefits $C_4$ | Social results $C_{41}$ | employment rate |
| | | outstanding alumni |
| | Economic performance $C_{42}$ | wealth value growth |

### 3.3. Evaluation Method

Grey theory is a theoretical tool to study the objective things in some information, some of the information is not clear and the uncertainty phenomenon of a theoretical tool, the innovation and entrepreneurship education evaluation index system has many levels and indicators with ambiguity, and the analytic hierarchy process is a method to deal with multi level and multi index decision-making problems.

(1) Construct judgment matrix. In Table 1, a comparison of the elements of each layer is established. This step should be completed by a number of experts to fill in the form, with the 1-9 scale method for the importance of the assignment, to the level of the importance of the two indicators, the structure of the judgment matrix.

(2) Calculate the weight of each indicator. Using the root mean square method to calculate the weight of the index, set the geometric mean value of every element in the matrix:

$$\overline{w_i} = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}, i = 1,2,3,...,n$$

The $\overline{w_i}$ is normalized, we can get $\overline{w_i} = \dfrac{\overline{w_i}}{\sum\limits_{j=1}^{n} \overline{w_i}}, i = 1,2,3...,n$, and the index weight is $A = (w_1, w_2, w_3)$.

(3) The conformance test. Check the experts in judging the importance of the indicators are consistent, to avoid the contradiction between the results. The consistency can be tested by random consistency ratios:

$$CR = \frac{CI}{RI}$$

Among them,

$$CI = \frac{\lambda \max - n}{n - 1}$$

$$\lambda \max = \sum_{i=1}^{n} \frac{(AW)^i}{nW_i}$$

$$AW = A \times W$$

The values can be found in the mean random consistency index table. When $CR \rangle 0.1$, the judgment matrix is need modified; when $CR \langle 0.1$, There is no logical contradiction in the judgment matrix.

The index of the evaluation index set is $V = (v_1, v_2, v_3, v_4, v_5)$, respectively, the degree of indicator as "very good", "good", " general ", "bad" and "very bad", the experts are graded according to the system, and the evaluation criteria are shown in Table 2.

**Table 2. Education Index Score Level Standard**

| Score | 10.0-9.0 | 8.0-7.0 | 6.0-5.0 | 4.0-3.0 | 2.0-1.0 |
|---|---|---|---|---|---|
| Evaluation index | Very good | Good | General | bad | Very bad |

The evaluation index of innovation and entrepreneurship education was evaluated according to the degree of M experts, and the evaluation sample matrix was obtained from the results.

$$D_{ij} = \begin{bmatrix} d_{ij11} & d_{ij12} & \cdots & d_{ij1m} \\ d_{ij21} & d_{ij22} & \cdots & d_{ij2m} \\ \vdots & \vdots & \ddots & \vdots \\ d_{ijk1} & d_{ijk2} & \cdots & d_{ijkm} \end{bmatrix}$$

The use of whitening weight function has four basic forms, according to the actual situation to determine. According to the evaluation grade V, Set ash class number is e ,e=1, 2, 3, 4, 5,, respectively, are shown in Table 3.

## Table 3. Evaluation of Grey Class and Whitening Weight Function

| estimated graynes | Grey number | definite weighted functions |
|---|---|---|
| $e = 1$ | $\otimes 1 \in [0,9,18]$ | $f_1(x) = \begin{cases} x/9, x \in [0,9] \\ 1, x \in [9,18] \\ 0, x \notin [0,18] \end{cases}$ |
| $e = 2$ | $\otimes 2 \in [0,7,14]$ | $f_2(x) = \begin{cases} x/7, x \in [0,7] \\ (14-x)/7, x \in [7,14] \\ 0, x \notin [0,14] \end{cases}$ |
| $e = 3$ | $\otimes 3 \in [0,5,10]$ | $f_3(x) = \begin{cases} x/5, x \in [0,5] \\ (10-x)/5, x \in [5,10] \\ 0, x \notin [0,6] \end{cases}$ |
| $e = 4$ | $\otimes 4 \in [0,3,6]$ | $f_4(x) = \begin{cases} x/3, x \in [0,3] \\ (x-6)/3, x \in [3,6] \\ 0, x \notin [0,6] \end{cases}$ |
| $e = 5$ | $\otimes 5 \in [0,1,2]$ | $f_5(x) = \begin{cases} 1, x \in [0,1] \\ (x-2)/1, x \in [1,2] \\ 0, x \notin [0,2] \end{cases}$ |

So the gray evaluation matrix is obtained.

$$R_{ij} = \begin{bmatrix} r_{ij11} & r_{ij12} & \cdots & r_{ij1m} \\ r_{ij12} & r_{ij22} & \cdots & r_{ij2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{ijk1} & r_{ijk2} & \cdots & r_{ijkm} \end{bmatrix}$$

Comprehensive evaluation of $C_{ij}$ and $C_i$, the evaluation results were recorded as $B_{ij}$ and $B_i$, in which, $B_{ij} = A_{ij} \bullet R_{ij}$, $B_i = A_i \bullet R_i$.

$$R_{ij} = \begin{bmatrix} B_{i1} \\ B_{i2} \\ \vdots \\ B_{ij} \end{bmatrix} = \begin{bmatrix} b_{i11} & b_{i12} & \cdots & b_{i1m} \\ b_{i21} & b_{i22} & \cdots & b_{i2m} \\ \vdots & \vdots & \ddots & \vdots \\ b_{ij1} & b_{ij2} & \cdots & b_{ijm} \end{bmatrix}$$

$B_i$ can be obtained by the comprehensive evaluation of $C_i$, The total evaluation results are recorded as $B$, $B = A \bullet R$.

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_i \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1m} \\ b_{21} & b_{22} & \cdots & b_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ b_{i1} & b_{i2} & \cdots & b_{im} \end{bmatrix}$$

Calculate the comprehensive evaluation value, V is the rating scale of the number vector, $U = B \bullet V^T$, $U$ is the final score.

## 4. Empirical Analysis

In this paper, we choose the case of innovation and entrepreneurship education of college students in North China University of science and technology. North China University of science and technology in industry, medicine, and economics, management, literature, law, art multidisciplinary coordinated development, with students education, postgraduate education, undergraduate education, continuing education, such as a full range of educational level of provincial key university. Schools always adhere to the service area, the training of applied talents of school characteristics. In the practice of innovation and entrepreneurship education, North China University of science and technology in order to strengthen the concept of professional education as a breakthrough, to foster entrepreneurial, applied talents as the goal, will be innovative entrepreneurship education and professional education integration, in-depth development of multi discipline support innovation and entrepreneurship curriculum system reform. In this paper, the grey theory and analytic hierarchy process are used to study the quantitative evaluation of innovation and entrepreneurship education.

In this paper, we choose five experts, according to the data of the North China University of science and engineering, and the rich experience and theoretical knowledge of the experts themselves, to make a judgment on the importance of each index. According to appendix expert's judgment, constructs the judgment matrix, and then uses the DPS software level single sort (many people) to calculate the weight of each index.

Data processing:

First class index weight is: $A = (0.345, 0.220, 0.301, 0.154)$

Two stage index weight is: $A_1 = (0.309, 0.409, 0.282)$

$$A_2 = (0.319, 0.421, 0.260)$$
$$A_3 = (0.7, 0.3)$$
$$A_4 = (0.6, 0.4)$$

Three stage index weight is: $A_{11} = (0.402, 0.299, 0.299)$

$$A_{12} = (0.433, 0.366, 0.201)$$
$$A_{13} = (0.325, 0.200, 0.174, 0.301)$$
$$A_{21} = (0.7, 0.3)$$
$$A_{22} = (0.6, 0.4)$$
$$A_{23} = (1)$$
$$A_{31} = (0.158, 0.116, 0.127, 0.345, 0.274)$$
$$A_{32} = (0.4, 0.6)$$
$$A_{41} = (0.3, 0.7)$$
$$A_{42} = (1)$$

Evaluation matrix:

$$D_{11} = \begin{bmatrix} 6 & 5 & 5 & 5 & 4 \\ 4 & 5 & 3 & 8 & 4 \\ 5 & 5 & 2 & 8 & 4 \end{bmatrix} \qquad D_{12} = \begin{bmatrix} 5 & 4 & 4 & 7 & 4 \\ 4 & 5 & 4 & 6 & 4 \\ 5 & 5 & 3 & 5 & 4 \end{bmatrix} \qquad D_{13} = \begin{bmatrix} 3 & 7 & 5 & 5 & 4 \\ 5 & 5 & 4 & 4 & 4 \\ 4 & 6 & 3 & 3 & 7 \\ 6 & 5 & 3 & 4 & 7 \end{bmatrix}$$

$$D_{21} = \begin{bmatrix} 4 & 4 & 4 & 8 & 4 \\ 8 & 7 & 4 & 6 & 4 \end{bmatrix} \qquad D_{22} = \begin{bmatrix} 7 & 5 & 5 & 5 & 4 \\ 7 & 7 & 5 & 6 & 4 \end{bmatrix} \qquad D_{23} = \begin{pmatrix} 4 & 4 & 6 & 4 & 4 \end{pmatrix}$$

$$D_{31} = \begin{bmatrix} 4 & 5 & 4 & 6 & 4 \\ 5 & 6 & 6 & 7 & 4 \\ 6 & 6 & 7 & 7 & 4 \\ 6 & 5 & 5 & 6 & 4 \\ 6 & 7 & 4 & 8 & 4 \end{bmatrix} \qquad D_{32} = \begin{bmatrix} 3 & 5 & 6 & 7 & 6 \\ 3 & 4 & 5 & 6 & 4 \end{bmatrix} \qquad D_{41} = \begin{bmatrix} 4 & 7 & 3 & 6 & 4 \\ 4 & 6 & 4 & 5 & 4 \end{bmatrix}$$

$$D_{42} = \begin{pmatrix} 3 & 5 & 3 & 6 & 4 \end{pmatrix}$$

Gray weight matrix:

$$R_{11} = \begin{bmatrix} 0.235754 & 0.303112 & 0.390408 & 0.070726 & 0 \\ 0.237188 & 0.279543 & 0.320203 & 0.163066 & 0 \\ 0.248227 & 0.292553 & 0.335106 & 0.124113 & 0 \end{bmatrix}$$

$$R_{12} = \begin{bmatrix} 0.236786 & 0.304440 & 0.355180 & 0.103594 & 0 \\ 0.228013 & 0.293160 & 0.374734 & 0.104093 & 0 \\ 0.206795 & 0.265879 & 0.372230 & 0.155096 & 0 \end{bmatrix}$$

$$R_{13} = \begin{bmatrix} 0.226721 & 0.291498 & 0.340081 & 0.141700 & 0 \\ 0.215928 & 0.277622 & 0.388671 & 0.117779 & 0 \\ 0.220790 & 0.283873 & 0.293747 & 0.201591 & 0 \\ 0.238452 & 0.306581 & 0.326202 & 0.128764 & 0 \end{bmatrix}$$

$$R_{21} = \begin{bmatrix} 0.248227 & 0.292553 & 0.335106 & 0.124113 & 0 \\ 0.289091 & 0.346055 & 0.305041 & 0.059812 & 0 \end{bmatrix}$$

$$R_{22} = \begin{bmatrix} 0.244066 & 0.313799 & 0.371731 & 0.070404 & 0 \\ 0.276228 & 0.355150 & 0.325759 & 0.042863 & 0 \end{bmatrix}$$

$$R_{23} = \begin{pmatrix} 0.223837 & 0.287791 & 0.366279 & 0.122093 & 0 \end{pmatrix}$$

$$R_{31} = \begin{bmatrix} 0.228013 & 0.293160 & 0.374734 & 0.104093 & 0 \\ 0.267943 & 0.344498 & 0.344498 & 0.043062 & 0 \\ 0.288541 & 0.370981 & 0.311624 & 0.028854 & 0 \\ 0.247552 & 0.318281 & 0.377040 & 0.057127 & 0 \\ 0.289091 & 0.346055 & 0.305041 & 0.059812 & 0 \end{bmatrix}$$

$$R_{32} = \begin{bmatrix} 0.253725 & 0.326218 & 0.321385 & 0.098671 & 0 \\ 0.214038 & 0.275191 & 0.350243 & 0.160528 & 0 \end{bmatrix}$$

$$R_{41} = \begin{bmatrix} 0.234702 & 0.301760 & 0.316848 & 0.146689 & 0 \\ 0.228013 & 0.293160 & 0.374734 & 0.104093 & 0 \end{bmatrix}$$

$$R_{42} = \begin{pmatrix} 0.200573 & 0.257880 & 0.326648 & 0.214900 & 0 \end{pmatrix}$$

$$R_1 = \begin{bmatrix} 0.2399 & 0.2929 & 0.3529 & 0.1143 & 0 \\ 0.2275 & 0.2926 & 0.3658 & 0.1141 & 0 \\ 0.2271 & 0.2919 & 0.3376 & 0.1434 & 0 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.2605 & 0.3086 & 0.3261 & 0.1048 & 0 \\ 0.2569 & 0.3303 & 0.3533 & 0.0594 & 0 \\ 0.2238 & 0.2878 & 0.3663 & 0.1221 & 0 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.2684 & 0.3380 & 0.3524 & 0.0612 & 0 \\ 0.2299 & 0.2956 & 0.3387 & 0.1358 & 0 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.2300 & 0.2957 & 0.3574 & 0.1169 & 0 \\ 0.2006 & 0.2579 & 0.3266 & 0.2149 & 0 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.2312 & 0.2925 & 0.3538 & 0.1224 & 0 \\ 0.2495 & 0.3123 & 0.3480 & 0.0902 & 0 \\ 0.2568 & 0.3253 & 0.3483 & 0.0836 & 0 \\ 0.2182 & 0.2806 & 0.3451 & 0.1561 & 0 \end{bmatrix}$$

Comprehensive evaluation:

$$B = A \bullet R = \begin{pmatrix} 0.2456 & 0.3108 & 0.3566 & 0.1113 & 0 \end{pmatrix}$$

$$U = B \bullet V^T = 6.5023$$

The performance score of the innovation and entrepreneurship education in North China University of science and engineering is low, and the gray weight matrix can be seen, all the gray matrix third column score is the highest, and the third column corresponds to the gray number $e = 3$, which indicates that the evaluation index of innovation and entrepreneurship education in North China University of science and engineering education is generally at the general level, which needs to be improved. But taking into account the North China University of science and technology belongs to the ordinary provincial colleges and universities, 985 or 211 colleges and universities, the existing achievements is worthy of recognition.

## 5. Conclusion

In this paper, we use the analytic hierarchy process and grey theory to carry out the quantitative evaluation of the innovation and entrepreneurship education of North China University of science and technology. The evaluation process takes into account the different influence factors, and gives the weight, the more objective reflection of the current situation of College Students' innovation and entrepreneurship education, the development of innovation and entrepreneurship for college students has guiding significance.

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