

# Research on the University Innovation and Entrepreneurship Education Comprehensive Evaluation Based on AHP Method

Ben Niu, Qianying Liu, and Yiming Chen

**Abstract**—Nowadays, innovation and entrepreneurship education in colleges and universities has been greatly valued and has obtained large-scale development in China. Meanwhile, "double innovation" education also has some worrying phenomena such as low quality and slow development. Systematic and scientific evaluation system is an important mean to ensure the effectiveness of entrepreneurship education, but it is still quite scarce. Therefore, this paper proposed an effective and comprehensive evaluation system to carry out the evaluation of entrepreneurship education in universities, so as to monitor the implementation process of entrepreneurship education and provide valuable feedback to promote the integrity of the "double innovation" education system. Afterwards, we used AHP and Delphi method to analyze the importance of the components of the evaluation system. Then, we conducted an empirical analysis, using the previous evaluation system, Delphi method and questionnaire survey to evaluate innovation and entrepreneurship education in Shenzhen University, and gave the results analysis. Finally, according to the survey results, this paper gave a series of analysis and suggestions, hoping to accelerate the development of "double innovation" education.

**Index Terms**—Innovation and entrepreneurship education, evaluation system, analytic hierarchy process.

## I. INTRODUCTION

Nowadays, since premier Li Keqiang from China put forward the slogan of "Mass entrepreneurship and innovation" at the Davos Forum in Summer in 2014, the government has successively proposed the implementation of national-level college students' innovation and entrepreneurship training program, deepening the education reforms of universities, and constructing demonstration bases for universities and research institutes. In a word, colleges and universities actively carry out "double innovation" education. And "double innovation" means innovation and entrepreneurship.

However, most colleges and universities have some misunderstandings about "double innovation" education. Many people think that "double innovation" is to encourage students to start businesses, or even practice activities after class. In the course of education, problems such as weak cultural atmosphere, lack of professional knowledge combination, shortage of teachers, and losing the emphasis

on institution building and post-control. This has led to the unsatisfactory phenomenon of low quality and slow development of "double innovation" education.

Since the traditional teaching system and content can no longer meet the needs, many scholars are studying the reform methods of existing teaching in universities, including the study of theory, curriculum system and practice reform [1], [2], comprehensive practical teaching system [3], the characteristics and prospects discipline system [4]. Obviously, a systematic evaluation system can correctly guide the education reform [5]. However, the research on the "double innovation" education evaluation is quite rare. Without doubt, it has become an urgent need to resolve the contradiction.

AHP is a framework for solving problems and a measurement theory [6]-[8] and is used as a decision analysis technique to evaluate complex multi-attribute options between one or more decision makers. Its greatest advantage is that it can handle the combination of qualitative and quantitative problems, and quantify the decision-maker's subjective judgment and experience. AHP has been widely used, especially for large-scale and trend-predicting problems involving multiple factors, standards, and scenarios [9]. At present, Liu etc. has offered employment of university students entrepreneurship education evaluation index system, it contains four primary indicators: curriculum, teacher, student and environment, 10 secondary indicators and 48 tertiary indicators [10]; Gao etc. had applied an improved three-scale AHP method. Although the calculation is simplified and the consistency test and adjustment are avoided, the accuracy is reduced [11]; Based on the AHP method, He etc. had studied the evaluation of entrepreneurial ability of Chinese agricultural higher vocational college students [12]. This paper aims to build a more time-sensitive evaluation system for education innovation and entrepreneurship, including the social environment, college construction and students themselves three aspects. The AHP method was used to rank the importance of the elements in the system. Delphi expert method and questionnaire were used to conduct empirical analysis, and the suggestions were given to prove the validity and usefulness of our study.

The remainder of this paper is organized as follows. The index analysis and index system of university innovation and entrepreneurship education evaluation is introduced in section II. Section III gives the detailed description of AHP analysis of education evaluation system. Section IV is the empirical analysis of the innovation and entrepreneurship education evaluation for Shenzhen University. Finally, we draw the conclusion and gave some suggestions in section V.

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II. UNIVERSITY INNOVATION AND ENTREPRENEURSHIP EDUCATION EVALUATION INDEX SYSTEM

Innovative entrepreneurship education is a practical education, aiming at cultivating talents with basic entrepreneurial qualities and pioneering personality. In fact, the "double innovation" education system is a complex system, which is influenced by external and internal factors. This paper will study the "double innovation" education evaluation from the social environment, college construction and students themselves three aspects [11]. Based on this, 13 indicators were selected to construct the university innovation and entrepreneurship education evaluation index system. The hierarchy and indicators are shown in Table I.

The definitions and references of indicators are described as follow: C1- The influence of universities local culture on the awareness of innovation and entrepreneurship, and the degree of risk preference [11], [13], [14]; C2- The simplicity of universities local administrative examination and approval procedures, site support, financial support, and tax incentives [13]; C3- The availability of bank's low-interest loans, angels/risk investments, microfinance guarantees and local government venture funds [13]; C4- Universities local economic development level, talent market, orderly market trading rules, technical support [13]; C5- Equipped with high-quality innovative entrepreneurship education faculty, introducing successful entrepreneurs as part-time teachers [2], [11], [14], [15]; C6- Set up a sophisticated innovative entrepreneurship education curriculum system, innovative entrepreneurship education and training, teaching methods are interactive, case-based new ways [2], [11], [15]; C7- Vigorously promote and carry out various innovation and entrepreneurial activities, and give students corresponding rewards and incentives [2], [11], [14]; C8- Provide adequate funding, a good entrepreneurial infrastructure, a school-enterprise cooperation platform based on industry, academia, and various safeguards [2], [11], [14]; C9- Have a good idea of innovative entrepreneur-ship education, campus culture and corresponding management system [11], [14]; C10- The ability to insight into opportunities, raise funds, manage and develop human resources, and awareness of innovation and entrepreneurship [14,15]; C11- Increased rate of students with innovative results after entrepreneurship education [11], [15]; C12- After receiving entrepreneurship education, the proportion of students who choose to start a business as a percentage of the total students [11], [14], [15]; C13-Participation rate in teaching and entrepreneurial simulation, out-of-town research, etc. and attendance rate in innovative entrepreneurship education courses [11].

A. Social Environment

As the external environment of university education, social environment can greatly affect the action and consciousness of universities and students. The government plays a leading role in the environment and is an important supporter of university entrepreneurship education. The government, issued the incentives, simple administrative examination and approval procedure and so on policy, build a good culture and business environment to cultivate innovative talents; Financial industries will give more economic support to startups. while the market determines the opportunities and survival of startups. A favorable environment for competition

and cooperation, enabling companies to grow vigorously.

TABLE I: UNIVERSITY INNOVATION AND ENTREPRENEURSHIP EDUCATION EVALUATION INDEX SYSTEM

Destination Layer	Criterion Layer	Index Layer
University innovation and entrepreneurship education evaluation (A)	social environment (B1)	Innovation and entrepreneurship culture (C1)
		Innovation and entrepreneurship policy (C2)
		Entrepreneurial Finance (C3)
		Entrepreneurial market (C4)
	university construction (B2)	Teachers level (C5)
		Course system construction (C6)
		Entrepreneurship competition, projects (C7)
		Construction of practice base (C8)
		Construction of university entrepreneurial atmosphere and system (C9)
	Students themselves (B3)	Innovation and entrepreneurship ability (C10)
		Increase rate of innovation (C11)
		Rate of entrepreneurship (C12)
		Rates of participation and attendance (C13)

B. University Construction

As the internal environment of "double innovation" education, the university is the implementer of entrepreneurship education and the key factor for the success of education. At present, colleges urgently need to deepen institutional reforms, improve existing entrepreneurial education programs, equip professional "double innovation" education faculty, externally hire enterprise personnel, set up new curriculum system, and vigorously carry out entrepreneurial competitions, but also to cultivate a strong entrepreneurial atmosphere.

C. Students Themselves

As the object of innovation and entrepreneurship education in universities, students are the most important variables. Students' innovative entrepreneurship, entrepreneurial awareness, and employability are both the foothold of "double innovation" education and the source of enthusiasm for students to participate spontaneously in innovative education. Colleges must achieve the goal of cultivating innovative talents by improving students' creativity, output of innovation, proportion of entrepreneurship, and enthusiasm for participation.

III. AHP ANALYSIS OF UNIVERSITY INNOVATION AND ENTREPRENEURSHIP EDUCATION EVALUATION SYSTEM

The Analytic Hierarchy Process (AHP), which was widely used in the field of sociology, was proposed by the American operations researcher Sadie Saaty.T.L. in the early 1970s

[6]-[8]. AHP analysis has the characteristics of combination of qualitative and quantitative analysis, and is suitable for the evaluation of innovation and entrepreneurship education. This paper uses AHP to evaluate innovation and entrepreneurship education in colleges and universities, and the process as follows: First, we find and analyze the relationship between various factors in the “double innovation” education system, and establish the hierarchical evaluation system shown in Table I. Then, through the Delphi method, the relative importance of the same level of indicators to the previous level is compared to construct the judgment matrix. After passing the consistency test, the single layer weight is calculated. Finally, the total ranking weight of the target is obtained from the top to the bottom.

A. Building a Judgment Matrix

For the comprehensive evaluation index system shown in Table I, we adopt the 1-9 scale method [16], and the specific content is shown in Table II. Through the expert scoring and reference to relevant research results and experience, the judgment matrix and weight of the criterion layer to the target layer are constructed and shown in Table III.

TABLE II: NUMERICAL SCALE SPECIFICATION IN AHP

Scale	Definition	Explanation
1	equal importance	Both elements are equally important
3	moderate importance	One element is slightly more important than the other
5	obvious importance	One element is obviously more important than the other
7	mighty importance	One element is mightily more important than the other
9	absolute importance	One element is absolutely more important than the other
2,4,6,8	the middle of above-mentioned scale	the middle of above-mentioned importance
$1/b_{ij}$	the reverse comparison	If the scale of element $i$ to element $j$ is $b_{ij}$ , and vice versa is $1/b_{ij}$

TABLE III: A-B'S JUDGMENT MATRIX

A	B1	B2	B3	W
B1	1	1/3	3	0.2583
B2	3	1	5	0.6370
B3	1/3	1/5	1	0.1047
$\lambda_{max}=3.039$	CI= 0.0193	RI=0.58		CR=0.0370

B. Hierarchical Single Sorting and Its Consistency Test

The meaning of hierarchical single ordering is the ranking weight of the relative importance of the same level factor to a factor of the previous level. After sorting, we need to perform a consistency check, which is to determine the allowable range of inconsistency in the judgment matrix. Usually, the consistency index CI is calculated to determine whether the matrix passes the consistency check. CI=0, indicating that the judgment matrix has complete consistency; CI is close to 0, and there is satisfactory consistency; the larger the CI, the more serious the inconsistency. The definition of CI is:

$$CI = \frac{\lambda - n}{n - 1} \nu \tag{1}$$

To measure the size of the CI, a random consistency indicator RI needs to be introduced, and the size of the RI varies with the order of the judgment matrix, as shown in Table IV:

TABLE IV: RANDOM CONSISTENCY INDEX RI STANDARD VALUE

Matrix dimension	1	2	3	4	5
RI	0	0	0.58	0.90	1.12

However, random factors may also lead to matrix inconsistency. Therefore, when testing the consistency of judgment matrix, the test coefficient CR which compare CI with RI should be introduced. If  $CR < 0.1$ , the judgment matrix is considered to be consistent, otherwise is [17]. The formula of CR is as follows

$$CR = \frac{CI}{RI} \tag{2}$$

In addition, in this paper, the maximum eigenvector and eigenvalue are calculated by the sum-product method [18]. First, we make the judgment matrix  $A=(a_{ij})_{n \times n}$ ,  $B=(b_{ij})_{n \times n}$ , and normalize A by column, as in formula (3). Then sum the normalized A which is B by the line, as in formula (4), and then normalize the vector W, as in formula (5), the obtained  $W = [W_1, W_2, \dots, W_n]$  is the feature vector, and finally calculate the maximum eigenvalue is shown in equation (6).

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (i,j=1,2, \dots,n) \tag{3}$$

$$\bar{W}_i = \sum_{j=1}^n b_{ij} \quad (i,j=1,2, \dots,n) \tag{4}$$

$$\bar{W}_i = \frac{\bar{W}_i}{\sum_{j=1}^n \bar{W}_j} \quad (i,j=1,2, \dots,n) \tag{5}$$

$$\lambda_{max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i} \quad (i,j=1,2, \dots,n) \tag{6}$$

According to this process, this paper constructs the judgment matrix of 13 indicators respectively belonging to B1 social environment, B2 college construction, and B3 students' own three criteria layers. The test results and weights are shown in Table V-VII:

TABLE V: JUDGMENT MATRIX OF C1-C4 INDICATORS UNDER B1 LAYER

B1	C1	C2	C3	C4	W
C1	1	1/5	1/2	1/7	0.0630
C2	5	1	3	1/2	0.3005
C3	2	1/3	1	1/5	0.1098
C4	7	2	5	1	0.5267
$\lambda_{max}=4.020$	CI= 0.0067	RI=0.90		CR=0.0075	

C. The Overall Ranking of the Indicators to the Target Level

According to the single-layer weight analysis, the importance degree of the index layer to the overall goal of university innovation and entrepreneurship education can be

obtained, that is, the total order of levels. The calculation results are shown in Table VIII:

TABLE VI: JUDGMENT MATRIX OF C5-C9 INDICATORS UNDER B2 LAYER

B2	C5	C6	C7	C8	C9	W
C5	1	4	1/2	2	3	0.2583
C6	1/4	1	1/5	1/3	1/2	0.0613
C7	2	5	1	3	5	0.4312
C8	1/2	3	1/3	1	2	0.1574
C9	1/3	2	1/5	1/2	1	0.0918
$\lambda_{max}=5.068$		CI= 0.017	RI=1.12	CR=0.0152		

IV. EMPIRICAL ANALYSIS

As a representative of the Frontier Innovation University, Shenzhen University is redefining the “Shenzhen Speed”. The proportion of consecutive graduates of the school to self-employed is higher than many undergraduate colleges, and the innovation achievements have continued to grow for many years. In the construction of teaching, Shenzhen University established the Guangdong Province Talent Training Model Innovation Experimental Zone, and integrated innovation and entrepreneurship education into the talent training plan. From the entrepreneurial practice, the university supports the whole process of student entrepreneurship, invites entrepreneurs to share experiences, and promotes the implementation of “College Students Innovation and Entrepreneurship Training Program” and “Challenge Cup”. Through the super-big innovation park, promoting the construction of campus creator space. This paper uses AHP, Delphi method and 200 online questionnaires to evaluate the innovation and entrepreneurship education of Shenzhen University, so as to discover the existing problems and guide the improvement direction of innovation and entrepreneurship education.

TABLE VII: JUDGMENT MATRIX OF C10-C13 INDICATORS UNDER B3 LAYER

B3	C10	C11	C12	C13	W
C10	1	1/2	1/2	2	0.1891
C11	2	1	1	3	0.3509
C12	2	1	1	3	0.3509
C13	1/2	1/3	1/3	1	0.1091
$\lambda_{max}=4.010$		CI= 0.0035	RI=0.90	CR=0.0039	

A. Determine the Indicator Score Value

This paper divides the evaluation criteria of Shenzhen University's innovation and entrepreneurship education into four levels, which constitutes the comment set: = {poor, general, better, good}, the corresponding score is set to (0—25],[25—50],[50—75],[75—100]. According to the results of ten experts and 200 questionnaires from the questionnaire star website, the scores of each indicator are calculated as shown in Table IX:

TABLE VIII: SUMMARY OF THE WEIGHTS OF EVALUATION INDICATORS FOR UNIVERSITY INNOVATION AND ENTREPRENEURSHIP EDUCATION

Destination Layer	Criterion Layer	Weight	Index Layer	Synthetic weight
University innovation and entrepreneurship education evaluation (A)	social environment (B1)	0.2583	Innovation and entrepreneurship culture (C1)	0.0163
			Innovation and entrepreneurship policy (C2)	0.0776
			Entrepreneurial Finance (C3)	0.0284
			Entrepreneurial market (C4)	0.1360
	university construction (B2)	0.6370	Teachers level (C5)	0.1645
			Course system construction (C6)	0.0390
			Entrepreneurship competition, projects (C7)	0.2747
			Construction of practice base (C8)	0.1003
			Construction of university entrepreneurial atmosphere and system (C9)	0.0585
	Students themselves (B3)	0.1047	Innovation and entrepreneurship ability (C10)	0.0198
			Increase rate of innovation (C11)	0.0367
			Rate of entrepreneurship (C12)	0.0367
			Rates of participation and attendance (C13)	0.0114

TABLE IX: SUMMARY OF SCORES FOR INDICATORS AT EACH LEVEL

B1 layer indicator	Score	B2 layer indicator	Score	B3 layer indicator	Score
Innovation and entrepreneurship culture (C1)	72.12125	Teachers level (C5)	67.74875	Innovation and entrepreneurship ability (C10)	64.13
Innovation and entrepreneurship policy (C2)	70.18625	Course system construction (C6)	64.1325	Increase rate of innovation (C11)	67.03
Entrepreneurial Finance (C3)	66.3475	Entrepreneurship competition, projects (C7)	70.11	Rate of entrepreneurship (C12)	62.6825
Entrepreneurial market (C4)	70.67875	Construction of practice base (C8)	67.9375	Rates of participation and attendance (C13)	63.9525
		Construction of university entrepreneurial atmosphere and system (C9)	69.2025		

B. Determination and Analysis of Comprehensive Evaluation Values

To calculate the comprehensive evaluation value of each layer, first from the index layer, according to formula 7, the

score E1 of B1 is calculated from S1 representing the scores of C1-C4 indicators and the weight W1, and so on, the score E2 of B2 and E3 of B3 is calculated. and then, according to the formula 8, the score E of the total target is obtained by the score set S and the weight set W of the B1-B3. The specific results are shown in Table X:

$$E_1 = W_1 * S_1 \quad (7)$$

$$E = W * S \quad (8)$$

TABLE X: SUMMARY OF COMPREHENSIVE SCORES AT ALL LEVELS

Layer	B1	B2	B3	A
Comprehensive score	70.15	68.71	64.62	68.65

The comprehensive evaluation score of Shenzhen University is 68.65, which is within the range of better grade (50-75]. The comprehensive score gives us some inspirations: From the overall point of view, Shenzhen University's investment in "double innovation" education got large return. The entrepreneurial environment in Shenzhen is very good, but in the venture finance, the government needs to strengthen communication with financial institutions, increase the availability of bank low-interest loans, angels/venture capital, microfinance guarantee Local government entrepreneurship funds to better assist college students in starting a business; In terms of university construction, Shenzhen University has more shortcomings. Although many entrepreneurial competitions and projects have been actively carried out, it is also necessary to introduce high-quality innovative and entrepreneurial education faculty and successful entrepreneurs as teachers, and to set up a comprehensive innovation and entrepreneurship education curriculum system, innovative teaching programs and strengthen the construction of practice base; The lack of students' own consciousness and ability is also a big problem in the education. First of all, according to the results, students are less motivated to participate in entrepreneurship courses and practice. Colleges must take improvement measures from the aspects of teaching methods, curriculum system and entrepreneurial atmosphere to improve students' enthusiasm and awareness of innovation and entrepreneurship, the quality of education and make a virtuous circle of education, and achieve the goal of improving students' ability to innovate and start a business eventually.

## V. CONCLUSION AND SUGGESTION

This paper constructs an innovation and entrepreneurship education evaluation system from three levels, and selects 13 representative indicators. Then, using AHP and Delphi method to calculate the weight of each level, the results show five small aspects of entrepreneurship competition and projects, teachers' level, entrepreneurial market, construction of practice base, innovation and entrepreneurship policy have a tremendous impact on "double innovation" education. From a macro perspective, university construction has a decisive role in the quality of education, the second is social environment, and finally is the students' own consciousness and ability. This shows that "double innovation" education must firstly be based on university construction. Finally,

through empirical analysis, we assessed the situation of innovation and entrepreneurship education in Shenzhen University, and monitored the implementation process of entrepreneurship education to guide the "double innovation" education. Based on the analysis results, we propose the following suggestions:

### A. Construct a Mechanism Integrating Innovation and Entrepreneurship Education with Professional Education

Colleges should abandon the past cramming teaching system and systematically carry out the reform from the aspects of teaching concept, teaching content, teaching methods, teaching staff, and entrepreneurial practice. Diverse entrepreneurship courses and practices are implemented for corresponding professions to realize the individualization and refinement of education. At the same time, through the various entrepreneurial competitions and practices to cultivate college students' awareness and ability.

### B. Develop "Mass Creative Space" and Cultivate "Entrepreneurial Culture"

Colleges and universities can set up an "innovation park", give financial and policy support, integrate off-campus entrepreneurial resources, and strengthen cultural exchanges and integration between universities and society. At the same time, we must carry out various entrepreneurial lectures, trainings, etc., increase innovation and entrepreneurship propaganda, explore advanced models of "double innovation", and create a strong cultural atmosphere.

### C. Establish an Entitative Management Agency

An independent running Innovation and Entrepreneurship Education College can coordinate the entrepreneurial resources of the whole school, and uniformly formulate and implement the construction and reform of entrepreneurial talent training programs, education curriculum system, teacher team, entrepreneurship practice, so as to more effective and orderly manage the operation of education.

### D. Improve the Teaching Management and Evaluation System of Innovation and Entrepreneurship Education

Universities should establish an evaluation mechanism for the innovation and entrepreneurship education, increase the weight of the "double innovation" education in the evaluation of teachers' titles, establish a credit mechanism composed of innovation, entrepreneurship and professionalism for students, and build the innovation and entrepreneurship educational reform projects identifying mechanism.

### E. Carry Out Continuous Education Evaluation

Universities should evaluate "double innovation" education for improving the design and implementation of educational programs at different stages, so as to monitor the implementation process of entrepreneurship education and test the effectiveness in real time. And put forward valuable feedback to promote the soundness of the "double innovation" education system.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

Ben Niu proposed ideas for the research; Qianying Liu and Yiming Chen collected and analyzed the data; All the authors wrote this article together; all authors had approved the final version.

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