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Evaluation of Innovative Entrepreneurship Education Based on the Analytic Hierarchy Process

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Innovative entrepreneurship can help to establish an innovative economy, and the quality of innovative entrepreneurship education in colleges will directly affect the innovative entrepreneurship of college students. Therefore, it is necessary to analyse and evaluate current entrepreneurship education in order to improve its outcomes. In this paper, the analytic hierarchy process (AHP), used for analyzing complex multi-level problems, is explained. Then, taking colleges X, Y, and Z as examples, a case study was carried out to evaluate "innovative entrepreneurship education in colleges". The results showed that innovation education achievements had the greatest impact on the overall evaluation of innovative entrepreneurship education, followed by student's practical ability, and resource allocation had the smallest impact. In respect to resource allocation, college Z had the highest score. College X had the highest score for students' practical ability and entrepreneurial education achievements. In the final comprehensive evaluation, college X had the highest score.

Keywords: innovative entrepreneurship, analytic hierarchy process, higher education, judgment matrix

1. INTRODUCTION

Since the beginning of the 21st century, rapid social and technological developments have increased the demand for jobs and facilitated economic progress (Barnard et al., 2019). However, the State's economic regulation is macro-controlled, which, although it supports employment, cannot directly increase the number and specific types of jobs (Johari et al., 2016). To ensure the ongoing development and enrichment of the economy, the market needs to provide more kinds of employment opportunities and projects. This requires innovative talents to foster entrepreneurship and provide jobs. Hence, innovative entrepreneurship education in colleges has become one of the important needs of innovative countries (Hamburg et al., 2017). However, for China, a developing country, the introduction of innovative entrepreneurship in tertiary education requires a new curriculum. Considering today's changing entrepreneurial environment (Tian, 2021), innovative entrepreneurship education should keep pace with the times. An excellent entrepreneurship education model can better cultivate innovative entrepreneurial talents, increase employment opportunities in new and diverse areas, and form a positive cycle (Passoni & Glavam, 2018). It is very important for colleges to accurately evaluate their innovative entrepreneurship offerings, beginning with an examination of teaching styles and their outcomes. This is fundamental to identifying areas requiring improvement and issues that need to be addressed. Tiago et al. (2015) have studied the advantages of entrepreneurship and its contribution to cultural development centered on marketing innovation. These researchers found that entrepreneurship education was the main contributor to entrepreneurial intention, and entrepreneurship education achievements had an impact on the entrepreneurial tendency. To study the impact of entrepreneurial education on college students' entrepreneurial orientation, Marques et al. (2018) developed a tool to measure entrepreneurial orientation and applied it to a

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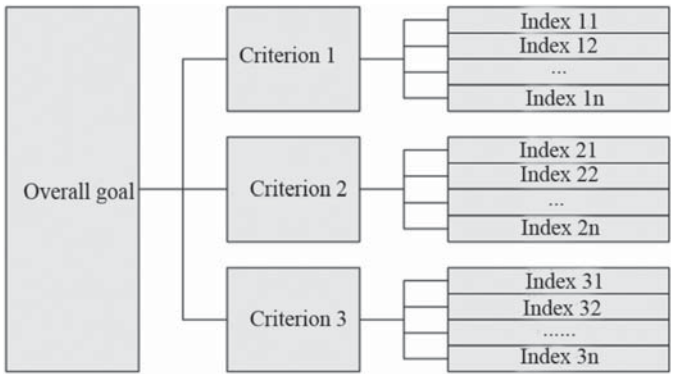

Figure 1 The basic structure of AHP.

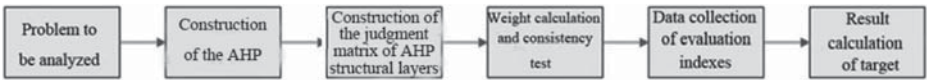

Figure 2 The basic steps of AHP in dealing with evaluation problems.

university. The study results showed that entrepreneurial education had a greater impact on business and social science students, and that family background and gender were the moderating variables affecting individual entrepreneurial orientation. Taking the students' perspective, Marti (2015) conducted empirical research on entrepreneurship education of engineering students. The research found that students had a strong interest in starting their own businesses, and that risk-taking ability, creativity, communication ability, and the ability to make business plans were the most important skills for a successful entrepreneur, and lack of experience and capital were the main deterrents. This paper examines the analytic hierarchy process (AHP) used for analyzing complex multi-level problems, and applies this to case studies of three colleges, X, Y, and Z.

2. ANALYTIC HIERARCHY PROCESS

An accurate evaluation of the innovative entrepreneurship courses or units offered by colleges can indicate the strengths and shortcomings of the curriculum and its delivery, and is crucial to identifying issues that need to be addressed in order to improve the education model (Fellnhofer & Puumalainen, 2017). Importantly, the tool used for this evaluation must be appropriate to ensure the accuracy of the results. In this paper, the innovative entrepreneurship education model implemented by three colleges is evaluated. The factors that can affect the quality of the education model are complex, diverse, and comprehensive. It can be said that the evaluation of entrepreneurship education in colleges constitutes a decision-making problem with complex, multi-level, and multiple characteristics. In this paper, AHP has been chosen to address this problem (Qu & Ding, 2021).

The core idea of AHP (Bai et al., 2017) is to "divide the whole into parts", which requires separating complex factors into multiple single sub-factors each of which needs to be considered separately and then ranked I order of importance. Figure 1 depicts the basic structure of the AHP. The target layer is the problem to be solved; the criterion layer is the preliminary division of the target layer, which is the intermediate structure; the index layer is the division of the criterion layer, which is the bottom structure, which consists of a more detailed analysis index related to the corresponding criterion layer. In practice, there are generally no more than nine criteria and indexes. On the one hand, too many criteria and indexes will make the construction of the judgment matrix troublesome, as the number of calculations will increase, and the problem will be divided too finely. In fact, only some indexes have a significant impact on decision-making, and other less influential indexes will hamper judgment.

The basic steps of evaluating complex problems with AHP are shown in Figure 2.

- Firstly, the problem to be evaluated is analyzed. In this step, discussions are conducted in meetings with relevant personnel or expert groups to identify the various factors that could affect the decision-making and the problem solution (Zoie, 2017). These factors form the basis for the subsequent construction of a hierarchy.
- After the meeting where opinions were gathered about the factors influencing the problem, the hierarchical structure of the problem to be considered is constructed.
- The judgment matrix of the criterion layer and index layer (Benedetto et al., 2015) is constructed for the subsequent weight calculation. The construction method takes the index group of the index layer under criterion 1 (Figure 1). As an example: when constructing the judgment matrix, the two indexes to be judged are compared to obtain the ratio of the influence of the two indexes on the indexes in the last layer (criterion 1). The influence scale is between one and nine, where one represents equally important and nine represents the most important. If the position is reversed in the comparison of indexes, the scale is converted to the reciprocal.
- After the judgment matrix is constructed, the index ranking of the corresponding layer of the matrix can be obtained; then, the weight of the index is obtained.

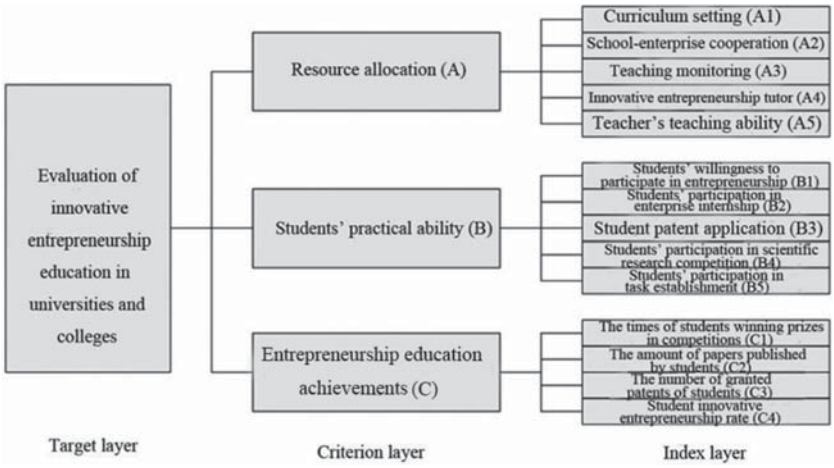

Figure 3 The hierarchical structure division of "evaluation of innovative entrepreneurship education in colleges".

However, although these weights have eliminated the interference between factors as far as possible by pairwise comparison and sorting, a small number of inconsistencies will emerge. These inconsistencies will eventually lead to obvious inconsistencies at the decision-making level as a result of layer-by-layer accumulation. Therefore, a consistency test is needed. The test formula (Miao & Ding, 2015) is as follows:

$$\begin{cases} CI = \dfrac{\lambda_{\max} - n}{n-1} \\ CR = \dfrac{CI}{RI}, \end{cases} \tag{1}$$

where CI stands for the consistency index, CR stands for the consistency ratio, RI stands for the average random consistency index (Singla & Kaushal, 2016), $\lambda_{\max}$ stands for the largest characteristic value of the judgment matrix (Asuquo & Umoh, 2015), and n is the order of the judgment matrix. When the CR of the judgment matrix is less than 0.1, it can continue to be used for weight calculation through consistency detection.

- According to the indexes in the index layer, an evaluation questionnaire is designed. The indexes in the questionnaire are scored, and the evaluation data are collected.
- The final result was obtained by a calculation based on the index evaluation data of the index layer and the weight calculated in step ④. Then, the problem described in the total target layer, i.e., the innovative entrepreneurship education in colleges, is evaluated according to the calculation results, and the score of every criterion in the criteria layer can also reflect the quality of the criterion.

3. CASE ANALYSIS

3.1 Analysis Project

Taking three colleges in Hebei province as the case studies, this study evaluated and compared the innovative entrepreneurship education implemented by the three colleges by using the analytic hierarchy process. In this study, the three colleges were named X, Y, and Z. There were 253 students in college X, 312 students in college Y, and 263 students in college Z participating in entrepreneurship education. Following a discussion with 20 invited experts, the evaluation of innovative entrepreneurship education in colleges at the decision-making level was divided into three main indexes in the criterion layer: resource allocation, students' practical ability, and entrepreneurship education achievements. Each of these indexes was further divided into four to five sub-indexes as shown in Figure 3. Resource allocation in the criteria layer was used for evaluating the educational resources that colleges can provide; "students' practical ability" reflected the practial ability of students under entrepreneurship education; "entrepreneurship education achievements" was used to evaluate the outcomes of implementing innovative entrepreneurship education; the main measurement index was students' entrepreneurial achievements (Katsaros et al., 2016).

3.2 Evaluation Method

$$\begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{bmatrix} 1 & \frac{1}{2} & \frac{1}{3} \\ 2 & 1 & \frac{1}{2} \\ 3 & 2 & 1 \end{bmatrix} \end{array} = \mathbf{M}. \tag{2}$$

The judgment matrix constructed by an expert for the criterion layer was taken as an example, as shown in equation (2). A, B, and C are the codes of the three factors of the criteria layer, and $\mathbf{M}$ represents the judgment matrix. The maximum characteristic value of $\mathbf{M}$ is calculated, 3.0092. CR is calculated according to equation (1), and the result was 0.0088, smaller than 0.1. Through the consistency test and according to $\mathbf{M}$, the weight is calculated, $A = 0.163$, $B = 0.297$, $C = 0.540$. For the index layer under each group of criterion layer, the weight of the judgment matrix and consistency tests were carried out in the same way. Other experts constructed the judgment matrix and calculated the weight using the same method. Finally, the average value was taken as the weight of factors in different layers.

Table 1 Evaluation index and data of innovative entrepreneurship education in three colleges.

Target layer	Criterion layer	Weight	Index layer	Weight	College X	College Y	College Z
Evaluation of innovative entrepreneurship education in colleges	A	0.165	A1	0.084	60.3	63.2	71.1
			A2	0.459	66.2	61.3	71.3
			A3	0.207	58.2	75.5	68.3
			A4	0.125	63.5	73.4	73.1
			A5	0.125	70.6	68.6	65.4
	B	0.299	B1	0.441	80.3	78.3	69.7
			B2	0.169	78.5	74.3	71.5
			B3	0.049	69.3	65.8	75.3
			B4	0.169	66.5	67.3	64.5
			B5	0.172	70.3	75.4	65.8
	C	0.536	C1	0.269	68.4	66.1	67.8
			C2	0.128	81.1	79.4	78.5
			C3	0.174	77.6	78.4	77.1
			C4	0.429	69.5	66.4	58.3

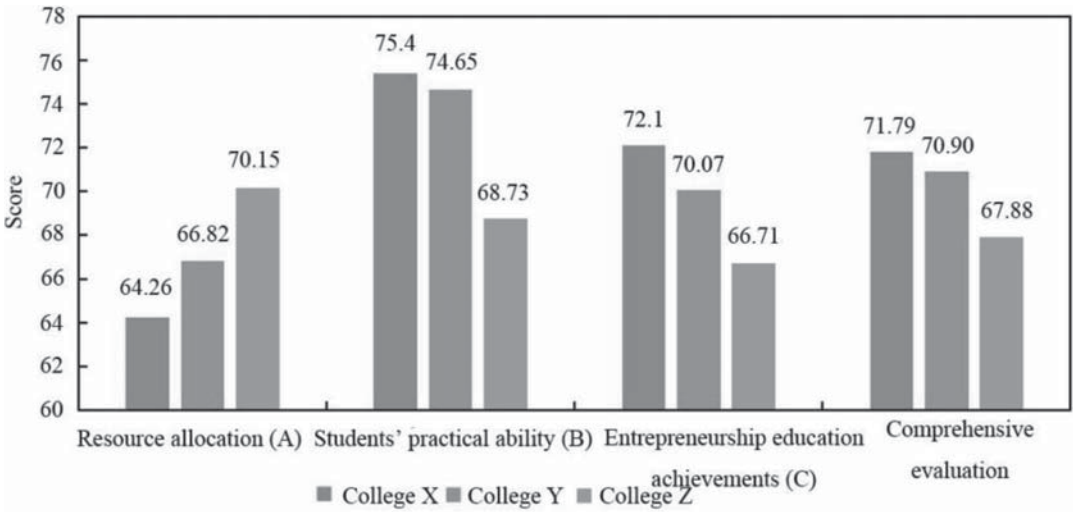

Figure 4 The criterion layer scores and comprehensive scores of three institutions.

After the division and weight calculation of factors in the hierarchical structure, the questionnaire was designed according to indexes in the index layer, and the evaluation of each index adopted the hundred-mark system. Finally, the average score of 20 experts was taken as the final score of each index.

4. EVALUATION RESULTS

In the AHP adopted in this study, 20 experts were invited to carry out the hierarchical division and weight design, and the evaluation data for the corresponding indexes were collected via a questionnaire survey. The final average results are shown in Table 1. There were three indexes, resource allocation (A), students' practical ability (B), and entrepreneurship education achievements (C) in the criteria layer. After the judgment matrix and consistency test, the weights were calculated; the results were 0.165, 0.299, and 0.536, respectively. There were five indexes under criterion A, five indexes under criterion B, and four indexes under criterion C. The average score of indexes in the index layer is also shown in Table 1, which will not be presented again here. The weight of the criteria layer in Table 1 indicates that according to the experts, when evaluating the quality of innovative entrepreneurship education in colleges, the most important factor was entrepreneurship education achievements, followed by students' practical ability, and the college's resource allocation.

In addition to showing the weights of the criteria layer and the index layer in AHP, Table 1 also shows the scores of different indexes of the three colleges. Although the separate comparison of the scores of the three colleges under the same indexes could reflect the quality of entrepreneurship education of the three colleges to a certain extent, it was assumed that all indexes were equally important to the evaluation of entrepreneurship education; however, in the actual evaluation, different indexes had different impacts on innovative entrepreneurship education. Therefore, it was comprehensively evaluated by the weight. AHP is a comprehensive evaluation method based on the weight of different layers after they have been divided. Figure 4 shows the criteria layer score and target layer score of the three colleges in the comprehensive evaluation using different weights. Figure 4 shows that college X had the highest score

for students' practical ability, followed by entrepreneurship education achievements and resource allocation; college Y had the same ranking as college X for the three criteria; college Z achieved the highest score for resource allocation, followed by student's practical ability and entrepreneurship education achievements. Finally, in the comprehensive evaluation based on the weight of three criteria, college X had the highest score, and college Z had the lowest score.

5. DISCUSSION

Innovation is essential to social progress, and economic development needs the expansion of the employment market. In addition to providing more jobs in existing industries, entrepreneurship can help to increase employment opportunities by creating new industries or expanding on current ones. In the face of rapid social changes, entrepreneurship also needs innovation. Young people in colleges face the problem of securing future employment, but they also possess good creativity and imagination. Therefore, colleges can foster the creativity of young people through innovative entrepreneurship programs, assist with their future innovative entrepreneurship, and promote the development of social entrepreneurship.

By means of AHP, the problem was divided into three criteria: resource allocation, students' practical ability, and entrepreneurship education achievements, and each criterion was sub-divided into several indexes. Then, the judgment matrix construction and weight vector calculation were carried out for these criteria and indexes. Experts were invited to evaluate the indexes. The final results obtained by weighting the three criteria indicated that entrepreneurship education achievements had the largest impact on the evaluation of entrepreneurship education, and the reason was relatively easy to understand. The ultimate goal of innovative entrepreneurship education is to improve students' innovative entrepreneurship ability. If students are showing no improvement despite the resources, then the model itself needs to be reconsidered.

In the case analysis, the quality of entrepreneurship education in three colleges was compared. There were many indexes in the index layer, and the indexes were relatively one-sided after division; moreover, the importance of each index was different. Therefore, the comprehensive treatment criteria in the criteria layer were compared. To be specific, the score of every criterion in the criteria layer was compared between the three colleges, i.e., the resource allocation, students' practical ability and entrepreneurship education achievements were compared between the three colleges.

The final results showed that college Z invested more in teaching resources, college X paid more attention to the improvement of students' practical entrepreneurship ability, and had achieved good results. On the other hand, college Y showed no strong, distinctive characteristics either way. Finally, through a comprehensive analysis of the criteria, it was found that college X with the worst resource allocation had the highest score, while college Z with the best resource allocation had the lowest score. There are several reasons for this result. Although college Z had the best resource allocation, the allocation of educational resources to improve students' practical ability was not reasonable, and it still maintained the traditional education mode, which emphasized entrepreneurship but neglected innovation. In addition, the teachers engaged in innovative entrepreneurship education in college Z had an inadequate understanding of the curriculum, while the corresponding professional teachers in college Z did not have an adequate understanding of innovative entrepreneurship education, i.e., teacher resources were mismatched. These factors led to students not acquiring the practical skills they needed for innovative entrepreneurship (they were given only a small amount of information during the course, but no in-depth knowledge about innovative entrepreneurship);, hence, this produced poor learning outcomes. College X had the worst resource allocation but achieved the best score for the evaluation possibly because it made the best use of the educational resources available by avoiding a mismatch between teachers and resources.

6. CONCLUSION

This paper gave a brief explanation of AHP that is generally used to analyze complex multi-level problems; the technique was applied to analyse the quality of innovative entrepreneurial education offered in three colleges, X, Y, and Z. The final results showed that: (1) in the judgment matrix constructed by 20 experts, entrepreneurship education results had a significant impact on the evaluation of innovative entrepreneurship education in colleges, followed by students' practical ability and resource allocation; (2) in terms of resource allocation, college Z had the highest score; in terms of students' practical ability and entrepreneurial education achievements, college X had the highest score; in the final comprehensive evaluation, college X had the highest score.

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