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AHP model for comprehensive assessment of college students' employability and its parameter adjustment methods

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ABSTRACT

Based on the Delphi method and relevant definitions, this paper determines the evaluation index system of college students' employability, adopts the hierarchical analysis algorithm (AHP) to calculate the weights of the evaluation indexes, and for the weights of the evaluation indexes do not satisfy the consistency test, adopts the Adaptive Gradient Algorithm (AdaGrad) to adjust the weight parameters so as to make them satisfy the consistency test, and arrives at the adjusted values of the evaluation indexes weights. The weights of the adjusted evaluation indexes are derived. Using the fuzzy comprehensive evaluation theory, a comprehensive assessment model of college students' completion ability was constructed, and then the research sample was evaluated and analyzed with the help of this model. It is calculated that the affiliation vector of the evaluation of college students' employability is (1.9466, 1.2539, 1.1123, 0.9752, 4.714), and the maximum affiliation value is 4.714, which can be inferred that the students of this university have good comprehensive ability of employment and can well face the employment pressure in the current society.

Keywords: hierarchical analysis algorithm, adaptive gradient algorithm, parameter adjustment, fuzzy comprehensive evaluation, college students' employment ability

1. Introduction

With the continuous development and expansion of China's higher education, the number of college graduates is increasing, and the employment pressure is also increasing, with this the employability of college graduates has certain problems [1-2]. On the one hand, some students encounter difficulties in the process of employment and cannot find jobs matching their majors, and although some students find jobs, the working conditions and salaries are not satisfactory [3-5]. Therefore, the establishment of college students' employability evaluation system is of positive significance in guiding college graduates to better choose employment positions and improve the quality of employment, which is

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not only related to the employment development of graduates themselves, but also related to the quality of education and teaching in colleges and universities and the development and progress of the society, and the Analytic Hierarchy Process (AHP) model is gradually being used in this context [6-9].

AHP model is a multi-level structure of decision analysis method, through the construction of hierarchical structure, determine the judgment matrix, use the eigenvector method to determine the weights, carry out hierarchical analysis, and make decisions [10-11]. In the evaluation system of employment ability of college graduates, AHP model can be widely used, which can construct the hierarchical structure of high-quality employment of college graduates, including first-level indicators and second-level indicators [12-14]. The first-level indicators include employment rate, employment salary, career prospects, etc., while the second-level indicators include specific evaluation indicators. The judgment matrix can be constructed for each indicator, and the importance of each indicator can be determined through expert surveys and statistics, and the influence degree of each indicator can be considered comprehensively. The weights of the indicators are determined by using the eigenvector method, and the final evaluation results are obtained [15-18].

Literature [19] proposed an improved AHP algorithm and used the three-scale method to construct the optimal transfer matrix and judgment matrix with high precision, avoiding the consistency check and adjustment of judgment matrix, and the improved hierarchical analysis method can reduce the amount of computation and ensure the correctness of the conclusion. Literature [20] introduced the AHP model to describe the problems encountered by graduates and the factors affecting their employment outcomes, and constructed the comparison matrix, revealing that the AHP model is a feasible strategy for solving the employment problem and shows effectiveness in solving complex decision-making problems. Literature [21] examined the evaluation of college students' employment quality, constructed an evaluation model of graduates' employment quality by establishing an evaluation index system, and revealed that the quality of employment can be improved from the aspects of learning and improving students' comprehensive quality. Literature [22] proposed an evaluation model of college students' employment quality based on hierarchical analysis method and analyzed the evaluation index system of college students' employment quality, showing that the hierarchical analysis method can realize the accurate evaluation of college students' employment quality. Literature [23] combined the hierarchical analysis method with entropy power method to construct an evaluation model of graduate employment ability, emphasized that the model provides a scientific and reasonable evaluation of graduate employment ability, and described the factors affecting graduate employment ability and other aspects.

Under the construction principle of the evaluation system, 4 first-level evaluation indicators and 23 second-level evaluation indicators were initially selected, thus forming the evaluation index system of college students' employability. Considering the actual evaluation effect of the system, the initially formulated evaluation index system was revised using the Delphi method, and finally consisted of 4 first-level evaluation indexes and 17 second-level evaluation indexes. In addition, in the process of calculating the weights of the indicators using the hierarchical analysis method, it was found that the weights did not pass the consistency verification. In view of this situation, optimization was carried out in the form of weight parameter adjustment, so that the weights of the indicators could meet the consistency test, and at the same time, the adjusted weight parameters were also calculated. Finally, the fuzzy comprehensive evaluation model is used to analyze the comprehensive assessment of the employment ability of college students in a university.

2. Construction of an evaluation index system for the employability of university students

2.1. *Employability of university students*

2.1.1. Theoretical definition of the concept of employability of university students. Employability is a complex concept and a concept of development, which is constantly endowed with new connotations of the times with the development of society, and has dynamic characteristics. Employability is also known as "employability", "employability", "employability", "vocational ability", etc. Employment is not just the ability of the employed person to have access to his or her own job, but it also represents an ability to be able to cope with changes in the workplace, which is an important ability, and it also encompasses the ability of the employed person to become different in his or her own position, to get the advancement that is required, and to continually improve this ability of his or her own.

2.1.2. Exploration of the structure of university students' employment capacity. The "structure of college students' employability" refers to the content of college students' employability. College students' employability is a multidimensional and multilevel ability complex, so its content should also be a complex comprehensive ability system. With the deepening of the research and the continuous updating of the model, scholars have their own views on the structural components of college students' employability, but they also have some commonalities, which can be summarized as follows: college students' employability is a mixed psychological structure composed of knowledge, skills and personality psychological characteristics. Its constituent factors can be roughly divided into intrinsic and extrinsic employability factors, which interact with each other to affect individual employment.

2.2. *Principles for the construction of the evaluation system*

The level of employability of university students, who have passed through several years of study in school and are moving towards society or taking up jobs after graduation, cannot be evaluated simply on the basis of whether they have been employed or not, and certain evaluation principles should be followed.

2.2.1. Scientific principles. College students, graduated from school to society or work, he is a "special product", this special product can be accepted by society or employers, it must depend on its quality. How to assess its quality must be based on the theory of modern marketing, must be in line with the law of social and economic development and the law of student growth, must be reasonable, and can not be blamed for everything.

2.2.2. Principle of operability. From the connotation of college students' employability, it is a collection of knowledge, skills, attitudes, personality qualities, psychological endurance, technological innovation or innovation and entrepreneurial ability related to specialized occupational positions (groups), etc. There are many indexes and dimensions to measure, and the influencing factors are diverse and complicated, therefore, when evaluating college students' employability, the index system should be simple, clear, convenient and practical, and easy to operate.

2.2.3. Principle of combining subjectivity and objectivity. In evaluating the employability of university students, on the basis of applying quantitative and objective evaluation indicators as far as possible, it is also necessary to take into account the influence of qualitative and subjective indicators, and to transform qualitative and subjective indicators into qualitative ways as far as possible. For example, the geographical difference and the industry background that the university takes and relies on as well as the popularity of the school and the program will affect the employability of the students. Therefore, it is necessary to combine subjective and objective and to transform subjective qualitative indicators into quantitative ways of evaluation as much as possible. At the same time, in the process of combining, the weight of the indicators should also be considered according to the local employment conditions at the time and the specific situation of individual students.

2.2.4. Principle of combining macro and micro levels. The level of employability of college students is not only related to micro factors such as the quality of individual students, the quality of specific employment positions and the degree of personal subjective satisfaction, but also related to objective factors such as the local socio-economic development situation at that time and the employment platforms and services provided by various levels of governments and schools. Therefore, when evaluating the employability of college students, the principle of combining macro and micro must be adhered to.

2.3. Evaluation system construction based on Delphi

The Delphi Method (also known as the Expert Consultation Method) is a strategy designed to gather expert consensus on a particular topic [24]. The core idea is to pool and synthesize expert advice through successive rounds of written consultation based on an anonymous feedback mechanism in order to reach a consensus on which a decision can be made. The Delphi method began to be adopted and utilized in a variety of studies, with a gradual increase in the use of the Delphi method, especially in educational research. The Delphi method has been widely used in the study of the evaluation criteria system and is considered as a preferred strategy for the selection of evaluation criteria. In this study, the Delphi method will be used to adjust and revise the initially constructed evaluation index system of college students' wisdom learning, refer to the experts' evaluation of the indexes and specific feedbacks, and then form a set of college students' employability evaluation system based on experts' opinions. The whole operation process includes: identifying a team of experts - designing and distributing consultation questionnaires - recovering and analyzing the questionnaires - formulating and sending the next round of questionnaires based on the feedbacks until a consensus is reached to form a revised version based on experts' opinions. During the execution of this study, two rounds of expert consultation were experienced to obtain the final index system for evaluating college students' employability.

2.3.1. Selection of experts. The results of the expert consultation have a crucial impact on the scientific validity and accuracy of the indicators and are considered a key way to assess the reliability and validity of the scale. Before applying the Delphi method to the expert consultation process, it is necessary to identify a suitable expert team. As for the ideal size of the expert team applicable to the Delphi method, there are no uniform guidelines. Some researchers advocate that an increase in the number of experts in the counseling process can enhance the accuracy of the results. While other scholars point out that the complexity of the consultation is closely related to the size of the expert team, and that an excessive number of experts may cause the research process to become overly complex and may adversely affect the results of the consultation. It was found that when the size of the expert team exceeded 10, the increase in the number of experts did not have a significant impact on the consulting outcomes. Therefore, different studies should determine the number of experts according to their size and needs.0 The general view is that a team of 10 to 20 experts is more appropriate for the Delphi method. For the specific situation of this study, the research team plans to select 16 experts in related fields for consultation.

2.3.2. Expert activation factor. When analyzing the accuracy of the results of expert advice, several key factors are typically assessed: the level of expert engagement, the consistency of opinions and the degree of expert authority. Expert engagement is usually measured by the return rate of the questionnaire, with a higher return rate indicating a higher degree of importance. The formula for this is:

$$\text{Recovery rate} = (\text{Number of inquiry forms recalled}/\text{Number of inquiry forms issued}) \tag{1}$$

In the first phase of this study, questionnaires were sent to experts by e-mail and WeChat, and all 18 questionnaires sent were responded to, i.e., the experts' positive degree was 100%, which indicates that the experts were highly interested in this study. In addition, some experts made suggestions on the improvement of the assessment criteria. As for the consistency of opinions, it is usually expressed in terms of the average score of each assessment criterion and further reflects the importance of these criteria. In the initial solicitation for this study, the average scores of all Level 1 assessment criteria were above 4, indicating a high degree of consensus among experts on the importance of these criteria. According to Osborne, when using the Delphi method for expert opinion elicitation, if at least 2/3 of the experts scored more than 4 on a study, it means that there is a consensus among experts about the study.

The degree of expert authority reflects the experts' self-assessment of the research question, and the scientific and rationality of the final evaluation index is influenced by the coefficient of expert authority. In the Delphi method, the authority coefficient of experts (Cr) is determined by the basis of experts' judgment on the problem (Ca) and the experts' familiarity with the content of the study (Cs). Its calculation formula is:

$$Cr = (Ca + Cs) / 2 \tag{2}$$

The data that need to be self-assessed by experts in this study are the basis of judgment (Ca) and the degree of familiarity (Cs) of the experts. The basis of judgment (Ca) is divided into four parts: theoretical knowledge, practical experience, reference to domestic and foreign literature and subjective judgment, and the degree of judgment is divided into three levels: large, medium and small.

2.3.3. Expert advice questionnaire. Based on the initially constructed index system for evaluating the employability of college students, this study carefully planned and implemented the first round of expert consultation questionnaire. In the beginning part of the questionnaire, the main idea of the study was clearly and succinctly stated to the experts, i.e., it was the questionnaire description part to ensure that the experts had a clear understanding of the purpose of the study. The second section contained basic information about the experts. The third part is a survey on the rationality of the first-level and second-level indicators of smart learning power, and experts were specifically asked about their familiarity with the system of these indicators, so as to obtain their initial feedback on the indicator system. In addition, indicator modifications are set at the end of each level of indicators, so that experts can fill in the modifications to the indicators. In the design process of the Delphi expert questionnaire, several key factors needed to be emphasized. The first is to ensure that the experts consulted fully understand the workflow of the Delphi method. The second is that the design of the questionnaire should be prescriptive to ensure that the experts are able to answer the questions easily and that the number of questions is not excessive. Care needs to be taken to avoid repetition or redundancy of questions to ensure that the questionnaire is efficient.

2.3.4. Coefficient of variation. After the collection and completion of the expert consultation questionnaire, quantitative statistical methods were used to assess the reasonableness of the indicators, and the necessary adjustments and optimizations were made accordingly. Quantitative statistical analysis means applying mathematical statistical tools to process and analyze the data of the indicators selected by the experts, so that the research results can be visualized. In this study, the evaluation is carried out by calculating the mean (M), standard deviation (SD) and coefficient of variation (CV) of the indicators, which are statistical quantities that represent the concentration trend, the degree of dispersion and the volatility of the data, respectively. The more obvious the concentration trend, the smaller the degree of dispersion, and the lower the volatility, the stronger the rationality and necessity of the indicator. The mean (Mean) is the average of all experts' evaluations of the rationality of the indicators, reflecting the degree of consensus of expert opinions. The standard deviation shows the dispersion of expert opinions. The coefficient of variation, which combines the information of the mean and standard deviation, is a relative measure for judging the consistency of expert opinions, which demonstrates the variability of different experts' views on an indicator, and is a key statistical indicator for judging the reliability of research results. The coefficient of variation, also known as the coefficient of variation or coefficient of dispersion, measures the relative dispersion of expert opinions by combining the mean and standard deviation of the data. The formula for calculation is:

$$\text{Coefficient of variation (CV)= Standard deviation (SD)/ mean value (M)} \times 100\% \tag{3}$$

In the Delphi method, the mean M, standard deviation SD, and coefficient of variation CV are usually used to determine the agreement of expert opinions. In this study, the mean value M>3.5 (70% of the rank value of the 5-level rating scale), the standard deviation SD<1, and the coefficient of variation CV is the ratio of the standard deviation D to the mean value M. The coefficient of variation is based on CV<0.25, and the smaller the CV, the higher the degree of synergy among experts on the evaluation indicators. Due to the large number of indicator items, the indicators at each level were numbered. The mean M, standard deviation SD and coefficient of variation CV were calculated for each of the primary, secondary and tertiary indicators using the SPSS27.0 statistical tool.

3. Construction of the AHP model and its parameterization

3.1. AHP model

Hierarchical analysis method (AHP) refers to a complex multi-objective decision-making problem as a large system, the objective is decomposed into multiple objectives or criteria, and then into a number of levels of multiple indicators (or criteria, constraints), through the qualitative indicators fuzzy quantitative method to calculate the level of the single ranking (weights) and the total ranking, in order to serve as a systematic method of the objective (multi-indicator), multi-scenario optimization of the decision-making method, which is more suitable for decision-making problems that have a hierarchical staggered evaluation indicators of the objective system, and the objective value is difficult to quantitatively describe the decision-making problem [25-26].

3.1.1. Hierarchical modeling. The objectives of the decision, the factors affecting it (decision criteria) and the object of the decision are categorized into the highest, middle and lowest levels according to their interrelationships, and the hierarchy is mapped out. The highest level refers to the purpose of the decision, the problem to be solved. The lowest level refers to the alternatives in decision making. The middle level refers to the factors to be considered, the guidelines for decision making. For two adjacent layers, call the top layer the objective layer and the bottom layer the factor layer.

3.1.2. Constructing judgment matrices. In determining the weights of the factors at each level, if the results are only qualitative, it is often not easy to be accepted by others, and therefore proposed a consistent matrix method, that is, not to compare all the factors together, but two by two, for this time the use of relative scales, in order to minimize the difficulty of comparing the factors with each other with different natures, in order to increase the degree of accuracy. For example, for a certain guideline, the program under which two to two comparisons, and according to the degree of its importance rating for the elements and elements of the importance of the comparison results. Table 1 shows the scale of proportionality, the nine levels of importance given in the table and the values assigned to them, and the matrix formed by the results of the two-by-two comparisons is called the judgment matrix.

Table 1. Scale of proportion

Factor i over factor j	Quantized value
Equally important	1
Slightly important	3
More important	5
Strongly important	7
Extreme importance	9
The median of two adjacent judgments	2,4,6,8

3.1.3. Hierarchical Single Ordering and Consistency Tests. Corresponding to the largest characteristic root of the judgment matrix λ eigenvector, after normalization (so that the sum of the elements of the vector is equal to 1) is recorded as W. The elements of W are the same level of factors for the previous level of factors of the relative importance of a factor of the ranking weights, a process known as the hierarchical single sort. Can confirm the hierarchical single ordering, it is necessary to carry out the consistency test, the so-called consistency test is to determine the permissible range of inconsistency for A. The consistency test is the process of determining the order of consistency. Where the unique nonzero characteristic root of the n-order consistent array is n. The largest characteristic root of the n-order positive reciprocal inverse array A, when and only when, A is a consistent matrix. Since λ continuous dependence, then the more λ is larger than n, the more serious the inconsistency of A. The consistency index is calculated by CI, and the smaller CI is, the greater the consistency. The eigenvector corresponding to the largest eigenvalue is used as the weight vector of the degree of influence of the compared factor on a factor in the upper layer, and the larger the degree of inconsistency, the larger the judgment error caused. Thus, the magnitude of the $\lambda - n$ value can be used to measure the degree of inconsistency of A. Define the consistency index as:

CI = 0, there is perfect consistency. cI close to 0, there is satisfactory consistency. the larger the CI, the more serious the inconsistency. To measure the size of CI, the stochastic consistency index R is introduced.

Where the random consistency indicator RI is related to the order of the judgment matrix, in general, the larger the order of the matrix, the greater the possibility of random deviation in consistency.

Considering that the deviation of consistency may be due to random reasons, when testing whether the judgment matrix has satisfactory consistency, it is also necessary to compare the CI and the random consistency indicator RI to derive the test coefficient CR, and in general, if CR<0.1, it is considered that the judgment matrix passes the consistency test, or else it does not have satisfactory consistency.

3.1.4. Hierarchical total ordering and its consistency test. Calculating the weights of the relative importance of all factors at a given level with respect to the highest level (the overall goal) is called hierarchical general ranking. This process is carried out sequentially from the highest to the lowest level.

When using the hierarchical analysis method, if the selected elements are inappropriate and their meaning is confusing, or the relationship between the elements is not clear, it will reduce the evaluation quality of the AHP method, and even lead to the failure of the AHP method decision-making. In order to ensure the rationality of the recursive hierarchical structure, it is necessary to grasp the relevant principles, firstly, when decomposing and simplifying the problem, grasp the main factors, and do not lack or increase. The second is to pay attention to the intensity of the relationship between the comparative elements, and the elements that are too different from each other cannot be compared at the same level.

3.2. Parameter adjustment

The judgment matrix describes the decision maker's verdict on different comparison factors, but the judgment is usually subjective and inconsistency may occur, i.e., the constructed judgment matrix may not meet the consistency requirements, resulting in the calculated weights being difficult to ensure the reliability of the decision. Therefore, before calculating the weights, it is usually necessary to carry out consistency detection and element value adjustment and correction of the judgment matrix to reduce the impact of subjective inconsistency on decision-making. In this paper, we propose an AHP consistency adjustment method based on the calculated weights from the judgment results, with the optimization goal of minimizing the difference between the full consistency matrix corresponding to the final calculated weights and the original judgment matrix, to adjust the judgment matrix, so that the weights can retain the original judgment information to the greatest extent. Based on the above principle, the gradient most rapid descent method is utilized to solve the optimal value, and the main steps are as follows.

3.2.1. Optimization objectives. Based on the above analysis, let $b=\left[b_{1,2},b_{2,3},\cdots,b_{N-1,N}\right]^T$ and set $p=f(b)=f(b_{1,2},b_{2,3},\cdots,b_{N-1,N})=\sum_{i=1}^{N}\sum_{j=1}^{N}(a_{i,j}-b_{i,j})^2$, then the final goal is to find the minimum value of $p=f(b)$ within the range of values.

3.2.2. Gradient calculation. To calculate the gradient of $p=f(b)$, the above equation can be written as:

$$p=f(b)=\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(a_{i,j}-b_{i,j})^2=\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left[(a_{i,j}-b_{i,j})^2+\left(\frac{1}{a_{i,j}}-\frac{1}{b_{i,j}}\right)^2\right] \tag{4}$$

where $b_{i,j}$ is obtained by solving for $b_n,n+1(1\le n\le N-1)$:

$$\frac{\partial b_{i,j}}{\partial b_{n,n+1}}=\begin{cases}\prod_{m=i,m\neq n}^{j-1} b_{m,m+1} & i\le n\le j-1\\ 0 & other\end{cases} \tag{5}$$

Then, the calculation yields the result of the derivation of $1/b_{i,j}$ on $b_{n,n+1}(1\le n\le N-1)$:

$$\frac{\partial\left(\frac{1}{b_{i,j}}\right)}{\partial b_{n,n+1}}=\begin{cases}-\prod_{m=i,m\neq n}^{j-1} b_{m,m+1}/b_{i,j}^2 & i\le n\le j-1\\ 0 & other\end{cases} \tag{6}$$

Then the derivative of p with respect to $b_{n,n+1}(1\le n\le N-1)$ can be calculated:

$$\begin{aligned}\frac{\partial p}{\partial b_{n,n+1}}&=\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left[2(a_{i,j}-b_{i,j})(-1)\frac{\partial b_{i,j}}{\partial b_{n,n+1}}+2(a_{i,j}-b_{i,j})\frac{1}{b_{i,j}^2}\frac{\partial b_{i,j}}{\partial b_{n,n+1}}\right]\\&=\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left\{\left[2\left(\frac{1}{a_{i,j}}-\frac{1}{b_{i,j}}\right)\frac{1}{b_{i,j}^2}-2(a_{i,j}-b_{i,j})\right]\frac{\partial b_{i,j}}{\partial b_{n,n+1}}\right\}\end{aligned} \tag{7}$$

Then, the gradient of p can be found according to equation (7):

$$\nabla=\left[\frac{\partial p}{\partial b_{1,2}},\frac{\partial p}{\partial b_{2,3}},\cdots,\frac{\partial p}{\partial b_{N,N-1}}\right]^{\mathrm{T}} \tag{8}$$

3.2.3. Data updates. The traditional gradient descent method has the same learning rate for each parameter, but in practice, the importance of different parameters is different, so in this paper, we use

Adaptive Gradient Algorithm (AdaGrad) for data updating, which uses different learning rates for different parameters, so that the objective function can converge faster.

Let the gradient cumulants be r, k denote the number of iterations, $k \geq 1$, initialize $r^{(0)} = 0$, and the cumulants are updated as follows:

$$r^{(k)} = r^{(k-1)} + H(\nabla^{(k)}, \nabla^{(k)}) \tag{9}$$

where $H(\nabla^{(k)}, \nabla^{(k)})$ denotes the Hadamard product of $\nabla^{(k)}$ and itself. The update formula for the gradient is as follows:

$$b^{(k)} = b^{(k-1)} - H\left(\frac{\gamma}{\delta + \sqrt{r^{(k)}}}, \nabla^{(k)}\right) \tag{10}$$

Where: γ is the learning rate. δ is a minimal quantity to avoid a denominator of 0.

Because the original judgment matrix elements are distributed in [1/9, 9], b the initial value of each element is also distributed in [1/9, 9], in order to avoid excessive adjustment, the γ size can be controlled so that the maximum adjustment is within a certain range.

3.2.4. Iterative calculations. Compute $b^{(k)}$ corresponding to $p^{(k)}$ when $|p^{(k)} - p^{(k-1)}| < \varepsilon$ stops iterating, where ε is a very small positive number. Assume that the number of selected generations is K at this point, and use $b^{(\kappa)}$ at this point as the final solution for b.

3.2.5. Calculation of weights. After obtaining the final b, the perfect agreement matrix B is constructed according to Eq. (10), and the corresponding weights can be computed based on any of its columns w. Taking the first column of matrix B as an example, which has a value of $[1, 1/b_{1,2}, 1/\prod_{m=1}^{2} b_{m,m+1}, \cdots, 1/\prod_{m=1}^{N-1} b_{m,m+1}]^{\mathrm{T}}$, it is normalized to obtain the weight w.

$$w = \frac{\left[1, 1/b_{1,2}, 1/\prod_{m=1}^{2} b_{m,m+1}, \cdots, 1/\prod_{m=1}^{N-1} b_{m,m+1}\right]^T}{\sum_{j=2}^{N}\left(1/\prod_{m=1}^{j-1} b_{m,m+1}\right) + 1} \tag{11}$$

Through the above method, the size and direction of the amount of change can be automatically adjusted according to the size of the gradient, accelerating the rate of matrix adjustment, making b converge to the minimum value point faster, and obtaining the matrix B with a smaller amount of change, and at the same time obtaining the corresponding weights w.

4. Fuzzy comprehensive evaluation of the employability of university students

4.1. Basic Theory

Fuzzy comprehensive evaluation method is an evaluation method based on fuzzy mathematical theory, and its basic theory includes:

1) Fuzzy set theory. The fuzzy comprehensive evaluation method is built on the basis of fuzzy set theory [27]. Fuzzy set theory is a mathematical tool for describing vagueness and uncertainty, which transforms fuzzy concepts and fuzzy information in the real world into mathematical fuzzy sets, and describes the affiliation of elements with fuzzy sets by means of the affiliation function.

2) Fuzzy judgment matrix. In the fuzzy comprehensive evaluation method, each evaluation index and level of the evaluation object is organized into a fuzzy judgment matrix. The elements in the fuzzy judgment matrix represent the fuzzy evaluation grade of the evaluation object under each index, which can be described by the affiliation function.

3) Fuzzy comprehensive evaluation function. The fuzzy comprehensive evaluation method carries

out comprehensive evaluation of the evaluation object by defining the fuzzy comprehensive evaluation function. The fuzzy comprehensive evaluation function weights and sums the fuzzy evaluation grades in the fuzzy judgment matrix to obtain the comprehensive evaluation results of the evaluation object. The weights can be determined by subjective assignment, statistical analysis or expert consultation.

4) Reasoning and decision-making of fuzzy comprehensive evaluation: in the fuzzy comprehensive evaluation method, through the reasoning and decision-making process of the fuzzy comprehensive evaluation function, the fuzzy evaluation grade of the evaluation object is transformed into a specific evaluation result.

4.2. Operational steps

1) Constructing a fuzzy judgment matrix. The collected data and information are organized into a fuzzy judgment matrix, with the rows of the matrix corresponding to the evaluation objects and the columns corresponding to the evaluation indicators. The data and information are transformed into fuzzy evaluation grades through the affiliation function in fuzzy mathematical theory.
2) Determine the weights and the affiliation function. According to the relative importance of the evaluation indicators, determine the weight of each indicator. The weights can be determined by subjective assignment, statistical analysis or expert consultation. At the same time, according to the specific situation, select the appropriate affiliation function to describe the relationship between the evaluation level and the indicator values.
3) Fuzzy comprehensive evaluation calculation. According to the fuzzy judgment matrix and weights, the evaluation object is comprehensively evaluated through the fuzzy comprehensive evaluation function. The fuzzy comprehensive evaluation function can use the weighted average method, weighted sum method, hierarchical analysis method, etc.
4) Result analysis and decision-making. The results of the fuzzy comprehensive evaluation are analyzed and interpreted, and methods such as fuzzy reasoning and fuzzy relational arithmetic can be used. Finally, according to the evaluation results, make the corresponding decision or put forward improvement suggestions.

5. Analysis of the assessment of employability of university students

5.1. Analysis of the process of constructing the evaluation system

5.1.1. Composition of expert members. The Delphi method is more cautious about the determination of members because it is the most crucial step. The selection of expert members is mainly based on the content of the topic. In this study, the following two conditions were followed in selecting the experts: first, they are familiar with the research content of instant classroom evaluation, and they can have their own unique insights into the relevant research content of the topic. The second is that they have some research in the related fields of immediate classroom evaluation and have more theoretical knowledge and rich experience. In summary, the expert members selected for this study are divided into two categories, and the specific information of the expert members is shown in Table 2. As can be seen from Table 2, the expert members consisted of 16 people, including 8 experts in employment guidance outside the school (male: 3, female: 5), and 8 teachers of employment guidance inside the school (male: 4, female: 4)

Table 2. Specific information for expert members

Type	Sex	Teaching years (years)	Quantity (people)	Total (person)
External employment guidance specialist	Male	10~20	3	16
	Female	10~30	5	
School employment advisor	Male	10~20	4	
	Female	10~30	4	

5.1.2. Distribution and recovery of expert questionnaires. The first round of the Delphi method questionnaire was distributed to 16 experts respectively, of which the electronic version was distributed to 9 experts and the paper version was distributed to 7 experts. The experts were completed and collected, and the results of the distribution and collection of the expert questionnaires are shown in Table 3. Based on the above formula for calculating the positive coefficient, the positive coefficient of the experts in the two rounds was 100.00%, corresponding to an effective rate of 93.75%.

Table 3. The distribution and recovery of the expert questionnaire

Name	Emission	Return quantity	Invalid questionnaire	Invalid rate	Positive coefficient	Recovery factor	Efficiency
First round of testing	16	16	1	0.0625	100%	100%	0.9375
Second test	16	16	1	0.0625	100%	100%	0.9375
Total	16	16	2	0.0625	100%	100%	0.9375

5.1.3. Expert authority factor analysis. As can be seen from the above, a total of 16 questionnaires were distributed and 16 were recovered, with a recovery rate of 100%, and the positive coefficient of experts is 100%. The statistical results of experts' authority coefficient are shown in Table 4, which is derived from experts' self-assessment, the authority coefficient of 16 experts is above 0.7, and 100% of experts' authority coefficients are above 0.75, so the degree of authority of expert members is high.

Table 4. Expert authority coefficient statistical results

Expert number	Familiarity (Cs)	Basis of judgment (Ca)	Expert Authority Coefficient (Cr)	Expert authority
1	0.9	0.9	0.9	High
2	0.8	0.9	0.85	High
3	0.9	0.8	0.85	High
4	0.9	0.8	0.85	High
5	0.8	0.7	0.75	High
6	0.7	0.8	0.75	High
7	0.8	0.8	0.8	High
8	0.9	0.7	0.8	High
9	0.8	0.9	0.85	High
10	0.7	0.8	0.75	High
11	0.7	0.8	0.75	High
12	0.7	0.9	0.8	High
13	0.9	0.9	0.9	High
14	0.8	0.8	0.8	High
15	0.7	0.8	0.75	High
16	0.7	0.8	0.75	High

5.1.4. Preliminary formulation of evaluation indicators. In the period of mass higher education, except for some high-level universities engaged in elite education, most colleges and universities have assumed the historical mission of cultivating application-oriented talents. Characteristics of applied universities include: talent cultivation goals and programs reflecting the needs of local social development, teaching and research highlighting the applicability, reflecting the teaching mode of University-Industry Cooperation, increasing the proportion of practical teaching, and emphasizing the proportion of “dual-teacher” teachers. It is because of this distinctive feature of applied universities that the evaluation mechanism of talent cultivation and graduates' employability should also have its own uniqueness and pertinence. By referring to the mature scale of college students' employability both at home and abroad, and following the principle of evaluation index system construction mentioned above, four primary indicators and 23 secondary indicators of teaching level, professional level, social competence and employability skills are selected as the factors influencing the employability of graduates of applied universities, and the evaluation indexes are preliminarily formulated as shown in Table 5.

Table 5. The evaluation index is preliminary

Theme	Primary index	Symbol	Secondary index	symbol
Employability of college students	Teaching level	Y1	Teaching plan	X1
			Basic course teaching level	X2
			Professional course teaching level	X3
			Practical course teaching level	X4
			Teaching staff	X5
			Teaching facilities	X6
			Extracurricular science and technology activities	X7
	Professional level	Y2	Professional fit	X8
			Professional achievement	X9
			Computer level	X10
			Foreign language proficiency	X11
			Communication and expression ability	X12
			Practical innovation ability	X13
			Relevant work experience	X14
	Social competence	Y3	Teamwork ability	X15
			Organization and coordination ability	X16
			Interpersonal skills	X17
			Student leadership experience	X18
			Social activity experience	X19
	Employability skills	Y4	Employment and career planning guidance	X20
			Employment counseling	X21
			Job search skills	X22
			Recruitment activities	X23

5.1.5. First round of evaluation indicator screening:

1) First-level indicators. With the help of the coefficient of variation to complete the first round of first-level evaluation indicators screening work, the first round of first-level indicators expert consultation results are shown in Figure 1, where M, SD, CV represent the mean, standard deviation and coefficient of variation, respectively. It can be seen that the coefficient of variation of the four first-level indicators is less than 0.25, which means that the four first-level evaluation indicators initially formulated are all retained.

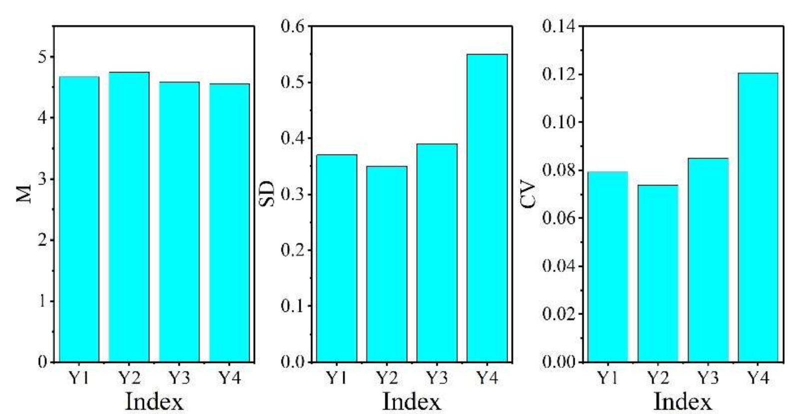
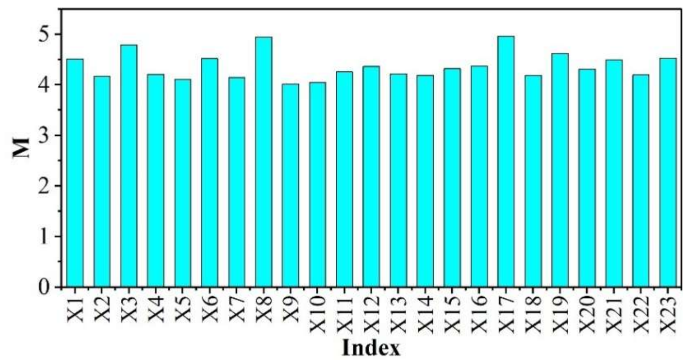
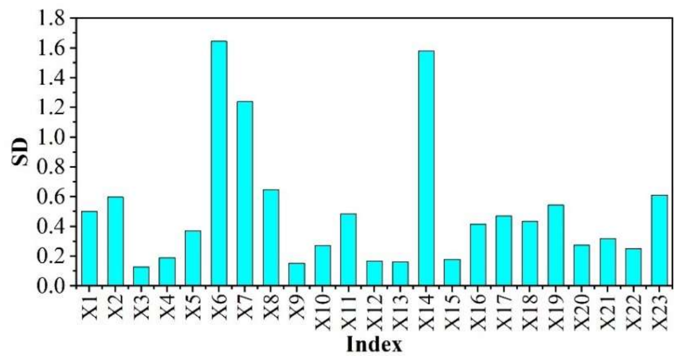


Fig. 1. Results of the first round of expert consultation on first-level indicators

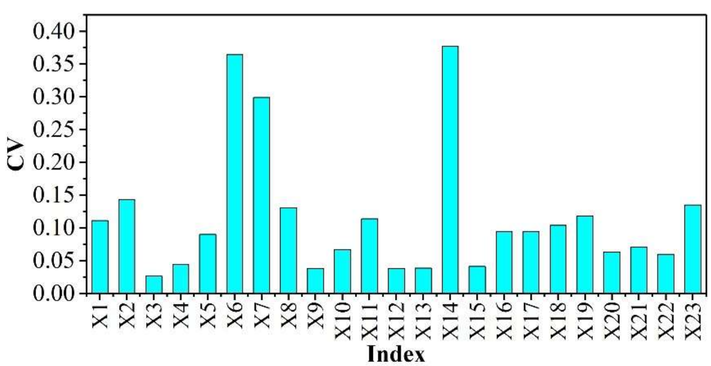
2) Secondary indicators. Adopting the same method described above, the preliminary formulation of secondary indicators was screened, and the results of the first round of secondary indicators screening are shown in Figure 2, where (a) ~ (c) are the mean value, standard deviation, and coefficient of variation, respectively. It can be clearly seen that the range of the mean value of the 23 secondary indicators is 4~5, the standard deviation is in the range of 0~1.7, and the corresponding coefficient of variation is located in the interval of 0~0.38. Since X6, X7, and X14 are larger than 0.25, they will be excluded from the treatment, and the rest of the secondary indicators are retained for treatment.



(a)Mean value



(b)Standard deviation



(c)Coefficient of variation

Fig. 2. The first round of secondary index screening results

5.1.6. Second round of evaluation indicator screening. Although one round of screening process was carried out for the above indicators, in order to better ensure the rigor of the research results, a second round of screening of evaluation indicators was then carried out for the initially formulated evaluation indicator system.

1) First-level evaluation indicators. Based on the coefficient of variation theory, the second round of first-level indicators were screened, and the results of the second round of first-level indicators screening are shown in Figure 3. The coefficient of variation of teaching level (Y1), professional level (Y2), social competence (Y3) and employment skills (Y4) are 0.07923, 0.07368, 0.08497 and 0.12061 respectively, which satisfy the condition that the CV is less than 0.25, so the four first-level indicators are retained.

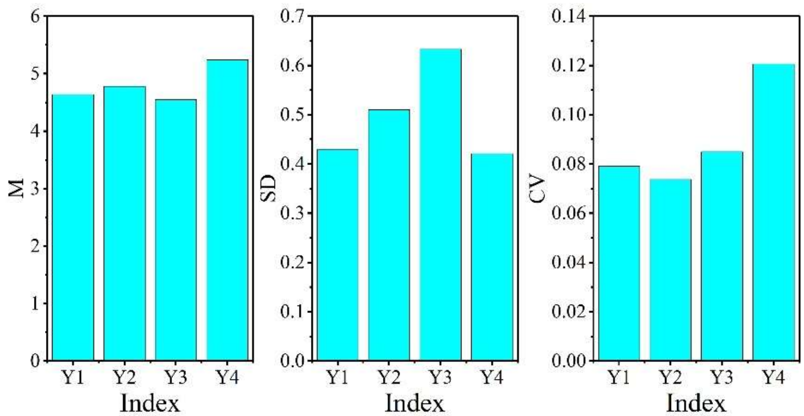
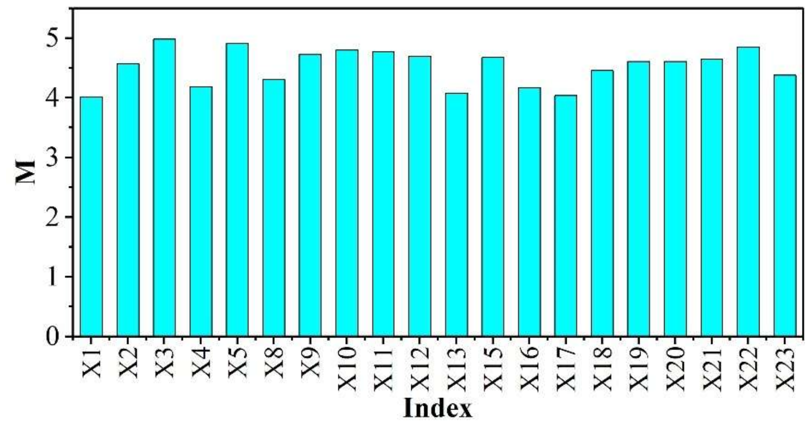
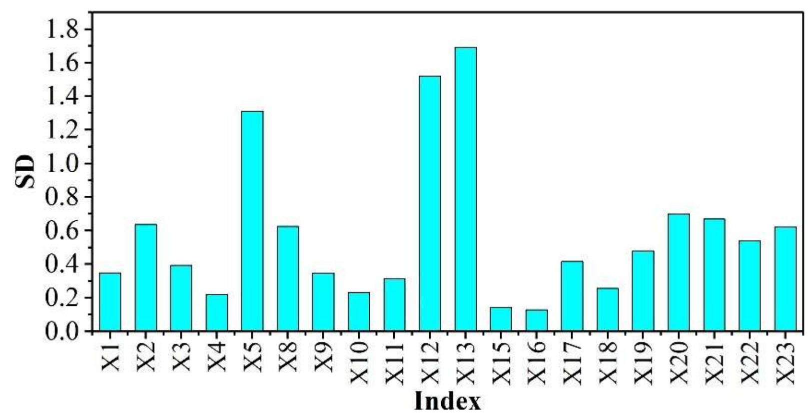


Fig. 3. The second round of primary index screening results

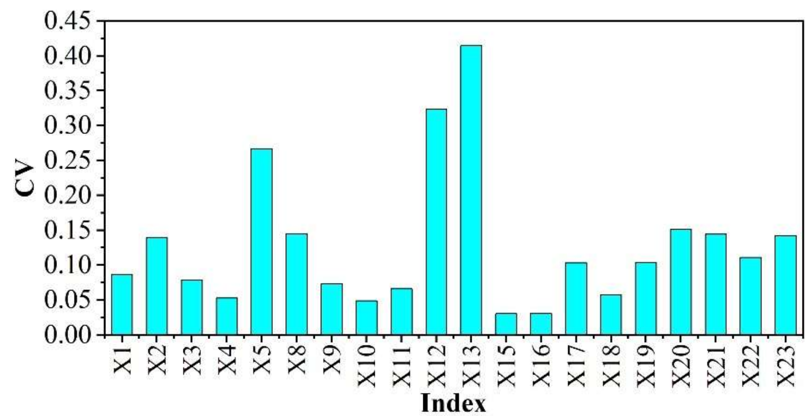
2) Second-level evaluation indicators. After completing the second round of primary indicators screening work, the second round of secondary indicators are finally screened, and the screening results are shown in Figure 4. Based on the performance of the coefficient of variation of the indicators in the figure, it can be seen that the value of the coefficient of variation of X5, X12 and X13 is greater than 0.25, which means that they will be excluded from the processing, and the remaining indicators will be retained for processing.



(a)Mean value



(b)Standard deviation



(c)Coefficient of variation

Fig. 4. Screening results

5.1.7. Determination of a system of evaluation indicators. After the above two rounds of evaluation index screening, the evaluation index system of college students' employability is finally determined, and the evaluation index system of college students' employability is shown in Table 6. It can be seen that the system consists of 4 first-level indicators and 17 second-level indicators, which provides a theoretical basis for the following example evaluation analysis.

Table 6. The evaluation index is preliminary

Theme	Primary index	Symbol	Secondary index	Symbol
Employability of college students	Teaching level	Y1	Teaching plan	X1
			Basic course teaching level	X2
			Professional course teaching level	X3
			Practical course teaching level	X4
	Professional level	Y2	Professional fit	X8
			Professional achievement	X9
			Computer level	X10
			Foreign language proficiency	X11
	Social competence	Y3	Teamwork ability	X15
			Organization and coordination ability	X16
			Interpersonal skills	X17
			Student leadership experience	X18
			Social activity experience	X19
	Employability skills	Y4	Employment and career planning guidance	X20
			Employment counseling	X21
			Job search skills	X22
			Recruitment activities	X23

5.2. Calculation of AHP-based weighting results

5.2.1. Hierarchical Single Ordering and Consistency Results Analysis. Referring to the 1 to 9 scale method above, the relative importance of each indicator is determined according to the expert's opinion, and the judgment matrix of each evaluation indicator is obtained, and the judgment matrix of the overall evaluation indicator is shown in Table 7, and the judgment matrix of the four first-level evaluation indicators is shown in Table 8 to Table 11. While calculating the weight value of each evaluation indicator, it was found that the CR of each indicator was greater than 0.1 not satisfying the consistency test.

Table 7. Overall evaluation index judgment matrix

Judgment matrix	Y1	Y2	Y3	Y4	Weighting	CR
Y1	1	5	2	3	0.3933	0.174
Y2	0.25	1	0.33	0.5	0.0757	
Y3	2	0.2	1	2	0.1589	
Y4	2	4	3	1	0.3721	

Table 8. Teaching level is subordinate to two index judgment matrix

Judgment matrix	X1	X2	X3	X4	Weighting	CR
X1	1	4	4	2	0.3694	0.108
X2	3	0.33	0.5	1	0.1303	
X3	1	0.5	1	3	0.1719	
X4	2	2	5	1	0.3284	

Table 9. Professional level subordinate to the two-level index judgment matrix

Judgment matrix	X8	X9	X10	X11	Weighting	CR
X8	1	1	2	2	0.2135	0.133
X9	4	1	5	0.25	0.2257	
X10	0.2	4	1	2	0.1698	
X11	3	3	5	1	0.3910	

Table 10. Social competence is subordinate to two index judgment matrix

Judgment matrix	X15	X16	X17	X18	X19	Weighting	CR
X15	1	3	1	0.5	4	0.2486	0.151
X16	0.33	1	0.5	0.5	4	0.1392	
X17	0.2	0.25	1	5	3	0.1641	
X18	0.5	0.5	0.33	1	5	0.1456	
X19	4	2	1	2	1	0.3025	

Table 11. Employment skills subordinate to two index judgment matrix

Judgment matrix	X20	X21	X22	X23	Weighting	CR
X20	1	0.5	0.2	3	0.1879	0.127
X21	2	1	2	0.2	0.2401	
X22	0.33	3	1	0.5	0.2130	
X23	1	2	2	1	0.3590	

5.2.2. Hierarchical General Ranking and Consistency Results Analysis. After deriving the ranking vectors under each criterion layer, the hierarchical total ranking is then performed, and the results of the hierarchical total ranking are shown in Table 12. The relative weights of the evaluation indicators are given, and it is found that CR = 0.122, which is less than 0.1, indicating that the above judgment matrix does not meet the consistency requirements.

Table 12. Hierarchy total sort result

X	Y				Resultant weight	Rank	CR
	Y1=0.3933	Y1=0.0757	Y1=0.1589	Y1=0.3721			
X1	0.3694				0.1453	1	0.122
X2	0.1303				0.0512	8	
X3	0.1719				0.0676	7	
X4	0.3284				0.1292	3	
X8		0.2135			0.0162	16	
X9		0.2257			0.0171	15	
X10		0.1698			0.0129	17	
X11		0.3910			0.0296	11	
X15			0.2486		0.0395	10	
X16			0.1392		0.0221	14	
X17			0.1641		0.0261	12	
X18			0.1456		0.0231	13	
X19			0.3025		0.0481	9	
X20				0.1879	0.0699	6	
X21				0.2401	0.0893	4	
X22				0.2130	0.0793	5	
X23				0.3590	0.1336	2	

5.3. Analysis of parameter adjustment results

Through the above calculation, it is concluded that the CR is greater than 0.1, which does not satisfy the consistency condition, so it is necessary to adjust the judgment matrix, and the adaptive gradient algorithm is used to adjust its fast parameters. The adjusted judgment matrix of the overall evaluation indicators is shown in Table 13, and the adjusted judgment matrix of the four first-level evaluation indicators is shown in Table 14 to Table 17. After the parameter adjustment, it is found that the CR values in the table are all less than 0.1, which greatly ensures the scientificity of the research results.

Table 13. The overall evaluation index judgment matrix after adjustment

Judgment matrix	Y1	Y2	Y3	Y4	Weighting	CR
Y1	1	0.25	0.5	2	0.2785	0.045
Y2	0.1	1	0.33	4	0.2374	
Y3	0.33	0.2	1	3	0.2627	
Y4	0.1	0.2	5	1	0.2215	

Table 14. The second level index judgment matrix of Y1 after adjustment

Judgment matrix	X1	X2	X3	X4	Weighting	CR
X1	1	0.33	0.33	3	0.2188	0.061
X2	2	1	0.5	0.25	0.2046	
X3	2	2	1	0.2	0.2737	
X4	3	4	0.1	1	0.3029	

Table 15. The second level index judgment matrix of Y2 after adjustment

Judgment matrix	X8	X9	X10	X11	Weighting	CR
X8	1	0.25	0.25	4	0.2447	0.088
X9	3	1	0.33	0.33	0.2616	
X10	0.2	0.25	1	4	0.2314	
X11	0.2	0.33	5	1	0.2623	

Table 16. The second level index judgment matrix of Y3 after adjustment

Judgment matrix	X15	X16	X17	X18	X19	Weighting	CR
X15	1	2	1	2	0.1	0.1966	0.042
X16	0.2	1	2	0.25	3	0.1856	
X17	0.33	0.5	1	2	2	0.2173	
X18	0.5	0.1	4	1	3	0.2132	
X19	0.25	0.5	0.5	5	1	0.1872	

Table 17. The second level index judgment matrix of Y3 after adjustment

Judgment matrix	X20	X21	X22	X23	Weighting	CR
X20	1	0.25	0.5	0.2	0.2299	0.037
X21	0.5	1	0.33	0.33	0.2793	
X22	0.2	0.2	1	0.5	0.2174	
X23	0.2	0.5	0.5	1	0.2734	

On the basis of the parameter values of single sorting weights satisfying the consistency test, the total hierarchical sorting and consistency test are carried out for the evaluation system of college students' employability, and the results of the total hierarchical sorting and consistency test are shown in Table 18. The table not only gives the relative weight data of each evaluation index, but also verifies that the weight of each index satisfies the consistency test (CR<0.1).

Table 18. Hierarchical total ordering and consistency test results

X	Y				Resultant weight	Rank	CR
	Y1=0.2785	Y1=0.2374	Y1=0.2627	Y1=0.2215			
X1	0.2188				0.0609	6	0.0092
X2	0.2046				0.0570	10	
X3	0.2737				0.0762	2	
X4	0.3029				0.0844	1	
X8		0.2447			0.0581	8	
X9		0.2616			0.0621	4	
X10		0.2314			0.0549	12	
X11		0.2623			0.0623	3	
X15			0.1966		0.0516	13	
X16			0.1856		0.0488	16	
X17			0.2173		0.0571	9	
X18			0.2132		0.0560	11	
X19			0.1872		0.0492	15	
X20				0.2299	0.0509	14	
X21				0.2793	0.0619	5	
X22				0.2174	0.0482	17	
X23				0.2734	0.0606	7	

5.4. *Fuzzy Comprehensive Evaluation of Employability of College Students*

5.4.1. Establishment of evaluation sets and comment sets. With a college 2023 graduates as the research object, taking into account the time of student employment in the epidemic prevention and control of the normalization stage, and to complete all the professional and employment guidance direction courses, so that college teachers, employers can be more objective and comprehensive to make the evaluation, the evaluation of college students' employability is a multi-factor, multi-indicator, multi-level comprehensive judging process, through the employment of multiple employability indicators constitute the total evaluation factor set $U=\{U_1,U_2,U_3,U_4,U_5\}$, establish the comment set $K=\{R_1,R_2,R_3,R_4,R_5\}$ = {poor, poor, general, better, good}, with n people to evaluate the γ_i indicators, then the constructed affiliation vector is expressed:

$$\gamma_i=\left(\frac{n_1}{n},\frac{n_2}{n},\frac{n_3}{n},\frac{n_4}{n},\frac{n_5}{n}\right) \tag{12}$$

5.4.2. Determination of the evaluation matrix. Based on the fuzzy comprehensive evaluation model, the evaluation matrix of college students' employability is constructed, and the evaluation matrix of college students' employability, the evaluation matrix is shown in Table 19. According to the data performance in the table, it is concluded that the evaluation affiliation vector of college students' employability in a school is (1.9466, 1.2539, 1.1123, 0.9752, 4.714), which concludes that college students' employability is good in the school due to satisfying the principle of maximum affiliation, so that the students are better able to find the matching jobs.

Table 19. Evaluation matrix

Index	R1	R2	R3	R4	R5
X1	0.1218	0.0609	0.0609	0.1218	0.2436
X2	0.114	0.114	0	0.114	0.228
X3	0.1524	0	0.0762	0	0.5334
X4	0.3376	0.0844	0.0844	0	0.3376
X8	0	0.1162	0.0581	0.1162	0.2905
X9	0.1242	0.0621	0.0621	0.1242	0.2484
X10	0.0549	0.1098	0.1098	0.0549	0.2196
X11	0.1246	0.0623	0.1246	0.0623	0.2492
X15	0.1548	0.0516	0	0.0516	0.258
X16	0	0.0976	0.0976	0.0488	0.244
X17	0.1713	0.0571	0.0571	0.0571	0.2284
X18	0.112	0.056	0.112	0	0.28
X19	0.1968	0.0984	0.0492	0	0.1476
X20	0.0509	0.0509	0.0509	0.1018	0.2545
X21	0.0619	0.1238	0	0.0619	0.3714
X22	0.0482	0.0482	0.0482	0	0.3374
X23	0.1212	0.0606	0.1212	0.0606	0.2424

6. Conclusion

This paper realizes the task of constructing the evaluation system of college students' employment ability based on the principle of evaluation system and Delphi method. The integrated hierarchical analysis method (AHP), adaptive gradient algorithm (AdaGrad), and fuzzy comprehensive evaluation model are used to make a comprehensive assessment of college students' employability.

1) In the preliminary formulated assessment system of college students' employability, the coefficients of variation of X5 (faculty strength), X6 (teaching facilities), X7 (extracurricular scientific and technological activities), X12 (communication and expression ability), X13 (practical and innovative ability), and X14 (relevant work experience) are less than 0.25, which are excluded, and the finalization of the assessment system of college students' employability for this study is determined, which consists of 4 primary indicators and 17 secondary indicators.

2) It is found that the weights of the indicators calculated by the hierarchical analysis algorithm do not satisfy the consistency, in this regard, the adaptive gradient algorithm is used to adjust the parameters, so that the CR value of the evaluation indicators is less than 0.1, to better ensure the feasibility of the results of the study.

3) Combined with the values of the evaluation index weights and the fuzzy comprehensive evaluation model, the subordination vector of the evaluation of college students' employability in a school is calculated as (1.9466, 1.2539, 1.1123, 0.9752, 4.714), and its maximum subordination is 4.714, which means that college students' employability is good in this school.

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