







In the above equation,  $b_{ij}$  represents the importance of different indicators and  $n$  represents the number of indicators. For calculation  $b_{ij}$ , the following 9-scale method can be used:

**Step 2: Normalize the judgment matrix.**

$$\bar{G}_x = \begin{bmatrix} \bar{b} & \bar{b} & \cdots & \bar{b} \\ \bar{b} & \bar{b} & \cdots & \bar{b} \\ \cdots & \vdots & \ddots & \vdots \\ \bar{b} & \bar{b} & \cdots & \bar{b} \end{bmatrix} = \begin{bmatrix} \frac{b_{11}}{\sum_{i=1}^n b_{i1}} & \frac{b_{12}}{\sum_{i=1}^n b_{i2}} & \cdots & \frac{b_{1n}}{\sum_{i=1}^n b_{in}} \\ \frac{b_{21}}{\sum_{i=1}^n b_{i1}} & \frac{b_{22}}{\sum_{i=1}^n b_{i2}} & \cdots & \frac{b_{2n}}{\sum_{i=1}^n b_{in}} \\ \cdots & \vdots & \ddots & \vdots \\ \frac{b_{n1}}{\sum_{i=1}^n b_{i1}} & \frac{b_{n2}}{\sum_{i=1}^n b_{i2}} & \cdots & \frac{b_{nm}}{\sum_{i=1}^n b_{in}} \end{bmatrix}$$

**Step 3: Determine the weight vector of the standard layer  $\gamma$ .** The specific calculation formula is as follows:

$$\gamma = \begin{bmatrix} \frac{\sum_{j=1}^n \bar{b}_{1j}}{n} & \frac{\sum_{j=1}^n \bar{b}_{2j}}{n} & \cdots & \frac{\sum_{j=1}^n \bar{b}_{nj}}{n} \end{bmatrix}^T$$

**Step 4: Test of weight vectors.** The weight vector  $\gamma$  is mainly determined by  $B(\gamma)_{n \times n}$ . The commonly used consistency indicator is  $D_R$ . The calculation formula of  $D_R$  is as follows:

$$D_R = \frac{D_1}{R_1}$$

$$R_1 = \frac{\gamma_{\max} - n}{n - 1}$$

$$\gamma_{\max} = \sum_{i=1}^m \frac{[B\gamma]_i}{m\gamma_i}$$

Among them,  $\gamma_{\max}$  represents the maximum value of the feature vector. In the above equation,  $m$  represents

the number of decision options, and the average consistency index  $R_1$  can be obtained by looking up Table 2.

If  $R_1 \leq 0.1$ , the judgment matrix  $G_x$  passed the consistency test and the indicator weights could be used. Otherwise, if  $R_1 > 0.1$ , the judgment matrix did not pass the consistency test, and a secondary evaluation is needed to correct the weight of the indicators until all indicators pass the test.

### Construction of a Comprehensive Index Model for Evaluating the Effectiveness of Graduate Education

Due to the fuzzy attribute of the evaluation of graduate education effectiveness, it is necessary to compare the specific differences in educational effectiveness through quantitative means. This paper introduces comprehensive indexing for comparison. Based on statistical thinking, the comprehensive index method standardizes different evaluation indicators and then obtains corresponding indices through weighting [38-40].

Referring to relevant studies [41-43], the modeling process of the comprehensive index method is mainly divided into two steps:

**Step 1 Standardization of data.** The specific formula is as follows:

$$X'_{ij} = 0.1 + \frac{X_{ij} - X_{j\min}}{X_{j\max} - X_{j\min}} \times 0.9$$

$X_{ij}$  represents the standardized value of the data,  $X'_{ij}$  represents the original value of the data,  $X_{j\max}$  and  $X_{j\min}$  respectively represent the maximum and minimum values.

**Step 2: Calculate the comprehensive index.** Use standardized data and indicator weights to obtain evaluation indices  $\rho$ .

$$\rho_i = \sum_{j=1}^s \gamma_j X'_{ij}$$

Among them,  $\gamma_i$  is the weight of the  $i$ -th indicator calculated by the Analytic Hierarchy Process, and  $X'_{ij}$  is the standardized value of the  $i$ -th data. By comparing the  $\rho_i$  sizes, the effectiveness of graduate education can be compared.

**Step 3: Evaluation result level.**

As the results obtained by using the comprehensive evaluation method are still difficult to directly reflect the "good" and "bad" evaluation results, it is possible to draw on the ideas of existing research and correspond the evaluation results to the corresponding levels. By referring to relevant practices [44-46], guidelines can be established between evaluation results and effectiveness levels.

Table 2.  $R_1$  Corresponding Values of Consistency Indicators.

n	$R_1$	n	$R_1$
1	0	6	1.26
2	0	7	1.36
3	0.52	8	1.41
4	0.89	9	1.46
5	1.12	10	1.49



## Data Sources

The relevant data in this research is obtained through the questionnaire survey. In the construction stage of the indicator system, selected experts mainly consist of teachers engaged in graduate teaching management at a certain university in Tianjin, including master's supervisors and graduate management personnel. There are 5 experts, all of whom have rich experience in graduate education management. In the stage of evaluating the effectiveness of graduate education, a random sampling survey is mainly conducted on graduate students in school. In order to analyze the effectiveness of the study, 120 graduate students from 2 colleges of a certain university in Tianjin are randomly selected for a survey. A total of 110 questionnaires are collected, with a response rate of 91.67%. Nine invalid questionnaires are deleted, and 101 are ultimately valid, with a validity rate of 91.8%.

## Results and Discussion

### Evaluation Index Results Based on Expert Group Decision-Making Method

In response to issues related to the effectiveness of graduate education, the research group invited 5 doctoral, professor, and master's supervisors from universities in Tianjin to form an expert evaluation group. The experts conducted five rounds of evaluation on the evaluation indicators. In the first round, various methods such as either/or, exclusion, and pairwise comparison were used to preliminarily rank the basic indicator library. Then, the expert group formed a unified opinion through online discussions. Finally, the indicator system as shown in Table 3. was obtained.

From the results, the expert group has mainly formed an indicator system of five dimensions: academic discipline construction, daily management, party and youth league construction, academic integrity, and curriculum ideological and political education. And following the principles of "measurable" and "concise", corresponding three-level indicators have been set.

Considering the principle of "student-centered", in terms of the three-level indicators, data is mainly obtained through graduate student ratings to assess students' satisfaction with educational outcomes.

For example, regarding the construction of academic discipline, a three-level indicator is set, "A11. How do you rate the integration of red genes into graduate student academic discipline in your university?"; In terms of daily management, set a three-level indicator "B11. How do you rate the integration of red genes into the daily management of graduate students in your university?"; In terms of party and youth organization construction, set a three-level indicator "C11. How do you rate the integration of red genes into graduate party and youth organization construction in your university?"; In terms of academic integrity, set a three-level indicator "D11. How do you rate the integration of red genes into graduate academic integrity education in your university?"; In terms of ideological and political education in the curriculum, a three-level indicator is set, "E11. How do you rate the integration of red genes into graduate courses in your university?". The construction of the indicator system provides an important basis for scientific and reasonable empirical research in the next stage.

### Weight Results of Evaluation Indicators for Graduate Education Effectiveness Based on Analytic Hierarchy Process

Applying the Analytic Hierarchy Process (AHP) model, the article obtains students' data on the effectiveness of integrating red genes into graduate education through a questionnaire survey. The results are shown in Fig. 1. Furthermore, the evaluation results of graduate education effectiveness are calculated through statistical software, and the weight values of different indicators are shown in Table 4.

The results show that the feature vectors of the five indicators A11, B11, C11, D11, and E11 are 0.908, 0.974, 0.937, 0.968, and 1.213, respectively. The maximum feature vector of the E11 indicator is 1.213, indicating that teachers and students pay the highest attention to the effectiveness of curriculum ideology and politics.

Table 3. Indicator System.

Primary indicators	Secondary indicators	Third level indicators
Evaluation indicators for integrating red genes into graduate education	A. Academic Discipline Construction	A11 How do you rate the integration of red genes into graduate student academic discipline in your university?
	B. Daily Management	B11 How do you rate the integration of red genes into the daily management of graduate students in your university?
	C. Party and Youth League Construction	C11 How do you rate the integration of red genes into graduate student party building in your university?
	Academic Integrity	D11 How do you rate the integration of red genes into graduate academic integrity education in your university?
	Course Ideological and Political Education	E11 How do you rate the integration of red genes into graduate courses at your university?

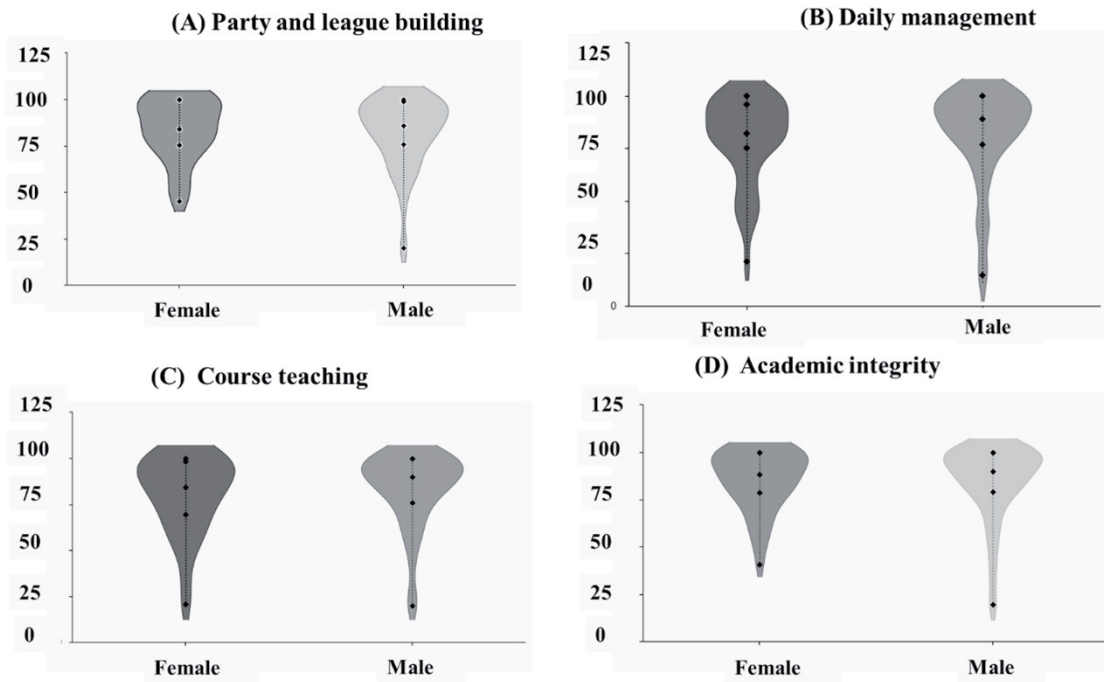


Fig 1. Questionnaire survey results for different indicators.

Therefore, as the educational management department of the school, it is necessary to attach importance to the construction of ideological and political education in the curriculum and provide training, supervision, guidance, motivation, and support to teachers who carry out graduate courses in ideological and political education.

Furthermore, from the weight results of the indicators, the weight values of A11, B11, C11, D11, and E11 are 18.16%, 19.47%, 18.75%, 19.36%, and 24.25%, respectively. A11 has the lowest weight, while E11 has the highest weight at 24.25%. The result is consistent with the feature vector, which is evidence that the data results are robust. All weight values remain within the range of [18% to 25%], indicating significant differences in the importance of the indicators.

When using the Analytic Hierarchy Process to calculate indicator weights, it is also necessary to conduct consistency checks on the results. As shown in Table 4., the value of CR is -0.701, which is less than 0.1, indicating that the judgment matrix has passed the test. The weight of the indicators calculated using AHP is significant.

#### Analysis of Evaluation Results of Graduate Education Effectiveness

According to the indicator system of the expert group decision-making method, combined with the Analytic Hierarchy Process to determine the weight of indicators, the comprehensive index method is used to obtain the

Table 4. Indicator Weight Results

Term	Feature vector	Weight value	Maximum eigenvalue	CI value
A11	0.908	18.16%	1.858	-0.785
B11	0.974	19.47%		
C11	0.937	18.75%		
D11	0.968	19.36%		
E11	1.213	24.25%		

Table 5. Consistency Test Results

Maximum eigenvalue	CI value	RI value	CR value	Consistency test results
1.858	-0.785	1.12	-0.701	adopt



it can be considered that the sample university has achieved significant results in cultivating graduate students to establish correct values.

### Discussion on the Evaluation Results of Graduate Education

From the foregoing research, it can be seen that the comprehensive use of the expert group decision-making method, analytic hierarchy process, and comprehensive index method are effective in evaluating the effect of graduate education. This model changes the traditional model of simple, qualitative assessment. From the results, the effect of postgraduate education is divided into seven grades: I, II, III, IV, V, VI and VII. The comprehensive evaluation score of the study sample is 1.00996, which is greater than 1.0, indicating a very good educational effect.

From the specific subgroups, the average evaluation score of subjects 1-25 is 0.99492, and its effect level is III. The average evaluation score of subjects 26-50 is 1.00996 (effect level II), and the average evaluation score of subjects 51-75 is 1.0008 (effect level II). The average evaluation score of subjects 76-101 is 1.033326733, and the effect grade is II. Therefore, both the whole and the group show that the effect of postgraduate education is at a good level.

### Conclusions

In the context of sustainable development, in order to achieve the sustainable goals of education and cultivate high-quality talents, the evaluation of the effectiveness of graduate education has important practical value. This article constructs an education effectiveness evaluation index system based on an expert group decision-making method from the perspective of integrating red genes into graduate education effectiveness evaluation. The weights of the indicators are determined through the Analytic Hierarchy Process, and finally, the evaluation results are formed using the comprehensive index method. The theoretical and practical value of this paper is as follows: it expands the theory of evaluation of the effect of postgraduate education through a comprehensive method; Through the empirical analysis method, the actual level of graduate education effect is accurately estimated. This paper draws the following conclusions:

(1) The evaluation index system for the effectiveness of graduate education can be carried out around five aspects: A. academic discipline construction, B. daily management, C. party and youth league construction, D. academic integrity, and E. curriculum ideological and political education. This article uses the expert group decision-making method and after 5 rounds of repeated inquiries, obtains a scientific and reasonable indicator system.

(2) The weights of indicators for evaluating the

effectiveness of graduate students exhibit typical heterogeneity. The weight values of the five indicators A11, B11, C11, D11, and E11 are 18.16%, 19.47%, 18.75%, 19.36%, and 24.25%, respectively. A11 has the lowest weight, with a value of 18.16%; E11 has the highest weight, with a value of 24.25%. The difference between the highest and lowest is 6.09%.

(3) The average score for evaluating the effectiveness of graduate education in the university where the survey samples are located is 1.00996, which is in the range [1.0, 1.1], corresponding to level II, indicating very good educational effectiveness. This indicates that the university has carried out a lot of work around the construction of graduate students' academic discipline, daily management, Party and Youth League building, academic integrity, and ideological and political education in courses. Paying attention to ideological and political education is conducive to improving the quality of talent cultivation.

This paper makes a systematic analysis of the comprehensive evaluation of graduate education from both theoretical and empirical levels. Although the research is somewhat innovative, there are still the following deficiencies, which are worth further study in the future:

(1) This paper uses the expert group decision method, analytic hierarchy process and comprehensive index method. Although these methods have reached good results, some other more effective methods, such as fuzzy comprehensive evaluation, can be explored.

(2) The data of a university in Tianjin is selected as a typical research sample. Subsequently, further empirical research can be conducted by expanding the sample.

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### Conflict of Interest

The authors declare no conflict of interest.

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