An Evaluation Method for Graduate Students' Academic Ethics Based on Fuzzy Matter-Element Model

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Abstract. As the core of high-level talent, graduate students play a crucial role in scientific and technological advancement and national revitalization. Enhancing the academic integrity and style of graduate students is crucial for maintaining the quality of education. In this study, an evaluation model of graduate students' academic ethics and academic style construction based on a fuzzy matter-element model was constructed. The influencing factors were analyzed through fishbone diagrams and incorporated into the model. In addition, this paper proposes a strategy for fostering academic ethics among graduate students in the new era and validates its effectiveness through case analysis.

Keywords: Fuzzy matter-element model; Graduate students; Academic ethics; Construction of study style; tactics

1 Introduction

Postgraduate education is a key component of China's higher education system, playing a crucial role in cultivating high-level talents, fostering scientific and technological innovation, and advancing social progress8[1].The establishment of academic ethics and study style for graduate students is a crucial guarantee for the quality of graduate education. It is closely linked to the scientific and technological innovation capacity of the country and social progress. The "Several Opinions of the Ministry of Education on Further Strengthening and Improving the Ideological and Political Education of Graduate Students" emphasized the need to enhance quality control and inspection, as well as to reinforce the standardized management system of degree-awarding units. In the context of the new era of socialism with Chinese characteristics, public concern about the quality of undergraduate and postgraduate education is rising. Despite this, there are still deficiencies in some degree-awarding institutions in terms of training conditions, management systems, implementation efforts, tutor responsibilities, students' ideological and political education, and academic ethics education[2]. On the other hand, in scientific research activities, some graduate students engage in academic misconduct to achieve quick results. This includes behaviors such as data falsification, plagiarism of others' work, and falsely attributing research achievements to relationships. These actions undermine the integrity of scientific research and significantly impact the moral standards of graduate students.

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Improving the academic ethics of graduate students plays an extremely important role in enhancing the academic ability and level of graduate students, as well as contributing to the academic development of China. The interaction among school spirit, teaching style, study habits, and academic ethics contributes to fostering a positive social atmosphere. In recent years, various scholars have conducted significant research on the topic from diverse perspectives. CAI Zhenyang, Chen Zhiyong et al.[3]first analyzed the practical challenges and difficulties in the construction of graduate studies under the background of double first-class construction. They explored the internal factors contributing to the predicament of study construction and ultimately proposed strategies for enhancing graduate study construction within the context of double first-class initiatives. From the perspective of academic standard education, Yu[4]explained the main contents and significance of constructing a graduate study style. They analyzed the main problems in academic standard education, including the slow reform of the academic evaluation system, and provided suggestions for improving the supervision system, supervisor guidance, and curriculum system. Li Mengjia and Huo Kai[5] first analyzed the subjective and objective factors influencing the development of graduate study styles in universities.In literature[6]and[7], the authors developed an academic survey to collect data by investigating the moral sentiment and professional responsibility of engineering institutes and faculty members during postgraduate recruitment, and analytically evaluated the collected data with common ethical theories and principles and relevant professional codes of conduct.

In summary, it has been found that a unified and perfect assessment system for fostering academic ethics and study style among graduate students has not yet been established. Therefore, this paper proposes an assessment and evaluation method based on the fuzzy matter-element model for developing graduate students' academic ethics and style. It designs an assessment and evaluation index system for this purpose and constructs a comprehensive model to assess and evaluate graduate students' academic ethics and style. This approach aims to provide a new perspective on assessing academic ethics.

2 Construction of assessment and evaluation index system for graduate academic ethics and academic style construction

Due to the absence of clear index norms, the assessment and evaluation system for constructing academic ethics and study style has not been standardized and enhanced. Moreover, its influencing factors are complex and subject to change. This paper utilizes the fishbone analysis chart to identify the factors influencing the development of graduate students' academic ethics and academic style. It then establishes an assessment and evaluation index system based on this analysis. In order to enhance the objectivity of the research, quantitative analysis is necessary. Therefore, when constructing the evaluation index system, it is important to adhere to the principles of operability, independence, logic, and comparability. On the premise of following these principles, this paper establishes an index system for evaluating graduate students' academic ethics, drawing from an analysis of the relevant literature on existing academic ethics index systems[8][9][10]. The index system comprises two levels of evaluation for graduate students' academic ethics and contributes to the development of an evaluation system for both academic ethics and academic style construction among graduate students, as illustrated in Table 1.

Table 1. Assessment and Evaluation Index System for Graduate Academic Ethics and Academic Style Construction.

Target layer	Criteria layer	Indicator layer (secondary indicator)
The goals of academic ethics and academic style construction for graduate students	Self factorsC_1	Academic encroachmentC_{11}
		Quoting the achievements of othersC_{12}
		Tampering and forging research dataC_{13}
		Multiple submissions of one manuscriptC_{14}
	Mentor factorsC_2	The degree of importance placed on academiaC_{21}
		Guide academic writing frequencyC_{22}
		Mentor's research levelC_{23}
		Mentor's research levelC_{24}
	Management factors in universitiesC_3	Mentor's research levelC_{31}
		Academic management systemC_{32}
		The Learning Path of Academic EthicsC_{33}
		The intensity of academic atmosphereC_{34}
	Other factorsC_4	Laboratory learning environmentC_{41}
		Competitive pressureC_{42}
		Performance evaluation systemC_{43}
		Lack of supervision and sanctionsC_{44}

According to the data in Table 1, it can be seen that the assessment and evaluation system of graduate students' academic ethics and study style mainly consists of four primary indicators and sixteen secondary indicators. Among them, the first-level indicators encompass the personal factors of graduate students, the factors related to supervisors, the management factors of colleges and universities, and other relevant factors. The factors affecting graduate students include four main categories: personal factors, such as academic integrity and proper citation of others' work; supervisory factors, including the level of academic support and frequency of academic writing; institutional factors, such as policies on academic misconduct and the level of competitive pressure.

3 Fuzzy matter-element model

In matter element analysis[11], "R" represents fuzzy matter elements, "M" represents things, "C" represents features, and the quantity value is denoted by "x." The names, features, and quantities of the components that constitute matter elements are referred to as the three elements of matter. If the quantity two in the matter element model is ambiguous, it is referred to as a fuzzy matter element. If a thing M has n features and their corresponding quantities, then R is called an n-dimensional fuzzy matter element. The combination of n-dimensional matter elements of m things forms the n-dimensional composite fuzzy matter element Rmn of m things, which is:

$$R_{mn} = \begin{bmatrix} & M_1 & M_2 & \cdots & M_n \\ C_1 & x_{11} & x_{21} & \cdots & x_{m1} \\ C_2 & x_{12} & x_{22} & \cdots & x_{m1} \\ \vdots & \vdots & \vdots & & \vdots \\ C_n & x_{1n} & x_{2n} & \cdots & x_{nn} \end{bmatrix} \tag{1}$$

where: M_i is the i th- thing, C_j is the first j feature, and x_{ij} is the ambiguity corresponding

to the j -th feature of the i -thing.

3.1 Preferential affiliation.

The ambiguity value corresponding to each individual index in the fuzzy matter element is subordinate to the membership degree of the corresponding fuzzy value of each evaluation index in the standard scheme, which is referred to as the preferential membership circle. Since the characteristic values of each evaluation index vary in their suitability for assessing the scheme, some are more effective when larger, while others are more effective when smaller. Therefore, different calculation formulas are utilized for varying membership degrees. The following forms are adopted to more comprehensively reflect the relative importance of the indicators in the water right allocation scheme:

The bigger the superior type:

$$\mu_{ij} = x_{ij} / \max x_{ij} \tag{2}$$

The smaller the superior type:

$$\mu_{ij} = \min x_{ij} / x_{ij} \tag{3}$$

where: μ_{ij} is the degree of preferential membership; $\max x_{ij}$、$\min x_{ij}$ are the maximum and minimum values of each evaluation index in each scheme, respectively, so that the fuzzy matter element R_{mn} of the optimal membership degree can be constructed:

$$Rmn = \begin{bmatrix} & M_1 & M_2 & \cdots & M_n \\ C_1 & \mu_{11} & \mu_{21} & \cdots & \mu_{m1} \\ C_2 & \mu_{12} & \mu_{22} & \cdots & \mu_{m2} \\ \vdots & \vdots & \vdots & & \vdots \\ C_n & \mu_{1n} & \mu_{2n} & \cdots & \mu_{mn} \end{bmatrix} \tag{4}$$

3.2 The entropy weight method determines the index weigh.

When assigning weight, the commonly used subjective method may lead to biased evaluation results due to personal biases. The entropy method, originating from thermodynamics and first applied to information theory by Shannon, is now widely utilized in various fields. In information theory, entropy represents the degree of confusion of information and is used to measure the amount of information. The index with more information has a more significant influence on decision-making, and the lower the entropy, the higher the order degree of the system. Therefore, information entropy can be used to assess the organization and usefulness of the acquired information. The significance of the index can be established using the judgment matrix to minimize human bias and produce evaluation outcomes that better reflect reality. Calculation steps include:

(1)Construct a judgment matrix R of m evaluation objects and n evaluation indicators:

$$R = (rij)m \times n(i = 1,2,\cdots,n,\ j = 1,2,\cdots,m) \tag{5}$$

(2)The judgment matrix R is normalized to obtain the normalized matrix B, whose elements are:

$$b_{ij} = (r_{ij} - r_{\min}) / (r_{\max} - r_{\min}) \tag{6}$$

In the formula, rmax,rmin is the most satisfied or the least satisfied among different objects under the same evaluation index.

(3)According to the definition of entropy, there are m evaluation objects and n evaluation indicators, and the entropy value of evaluation indicators is determined as follows:

$$H_i = -\frac{1}{\ln m}\sum_{j=1}^{m} f_{ij} \ln f_{ij}$$
$$f_{ij} = b_{ij} / \sum_{j=1}^{m} b_{ij}, i = 1,2\cdots, n; j = 1,2\cdots, m; 0 \le Hi \le 1 \tag{7}$$

(4)Calculate the upper weight W of the parameter, the calculation formula is as follows:

$$W = (\omega_i)_{1\times n}, \omega_i = (1 - H_i)/(n - \sum_{i=1}^{n} \mathrm{H_i}) \tag{8}$$

As can be seen from the above formula, the smaller the extraction value, the larger the entropy weight, indicating that the information content of the corresponding evaluation index is more effective and the evaluation index is more important. Conversely, the greater the entropy of the index, the smaller the entropy weight, and the less important the index.

(5)Calculation of close degree of academic moral evaluation of graduate students:

$$\rho H_i = 1 - \sqrt{\sum_{i=1}^{n} W_i \times a_{ij}} \tag{9}$$

The evaluation set refers to the collection of outcomes from assessing the target. According to the current situation of graduate students' academic ethics and experts' suggestions, this paper categorizes the evaluation of graduate students' academic ethics into five levels. Therefore, when n=5 is considered, the evaluation scale for graduate students' academic ethics can be defined as follows: V={v1, v2, v3, v4, v5}={Excellent, Good, Fair, Pass, Fail}.

4 Evaluation index weight

The Analytic Hierarchy Process (AHP) is a method that empowers subjectivity. In order to enhance the scientific nature of empowerment, subjective empowerment is typically quantified, and empowerment is implemented hierarchically based on the criterion layer and the index layer. When assigning weights, the subjective decision-maker compares the weights of all decision indicators in pairs and conducts a consistency test. Therefore, the Consistency Index (CI) is used to measure the deviation from consistency of the judgment matrix in order to enhance judgment accuracy. The test formula is as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{10}$$

In the formula, "n" represents the order of the matrix and is the principal eigenvalue. When the order is greater than 2, the consistency of the judgment matrix is tested by calculating the compatibility ratio (CR). If the Consistency Ratio (CR) is less than 0.1, the judgment matrix is considered to meet the consistency requirements.

$$CR = \frac{CI}{RI} \tag{11}$$

Where, CI is the calculation compatibility index; RI is a random consistency index.

Step1: Within permissible limits. The meaning of empowerment is shown in Table 2:

Table 2. Meaning of weights assigned by AHP method indicators[12].

ScaleAij	Implication
1	The i indicator is just as important as the j indicator
3	The i indicator is slightly more important than the j indicator
5	Index i is significantly more important than index j
7	The i indicator is much more important than the j indicator
2,4,6,8	The median of the above two judgments

Step2: Standard layer coefficients are shown in Table 3.

Table 3. Criterion level judgment matrix Z-Ci.

Z	C_1	C_2	C_3	C_4	ω_i
C1	1	5	6	8	0.62
C_2	3/5	1	2	7	0.21
C_3	1/6	1/2	1	4	0.12
C_4	1/8	1/7	1/4	1	0.05

λ_{max} = 4.23 ,RI=0.9,*CI*=0.08,*CR*=0.07＜0.1.

Step3: Assign factor weights to postgraduates themselves, as shown in Table 4.

Table 4. Self-factor judgment matrix of graduate students C1-C1ji.

Z	C_{11}	C_{12}	C_{13}	C_{14}	ω_i
C_{11}	1	2	3	2	0.44
C_{12}	1/2	1	2	3	0.26
C_{13}	1/3	1/2	1	4	0.19
C_{14}	1/2	1/3	1/4	1	0.11

λ_{max} = 4.16 ,RI=0.9,*CI*=0.05,*CR*=0.06＜0.1.

Step4: Mentor factor judgment matrix,as shown in Table 5.

Table 5. Mentor factor judgment matrix C2-C2ji.

Z	C_{21}	C_{22}	C_{23}	C_{24}	ω_i
C_{21}	1	2	2	3	0.39
C_{22}	1/2	1	1/3	3	0.18
C_{23}	1/2	3	1	5	0.35
C_{24}	1/3	1/3	1/5	1	0.08

λ_{max} = 4.22 ,RI=0.9,*CI*=0.07,*CR*=0.07＜0.1.

Step5: The weights of university management factors are assigned, as shown in Table 6.

Table 6. Judgment matrix of university management factors C3-C3ji.

Z	C_{31}	C_{32}	C_{33}	C_{34}	ω_i
C_{31}	1	2	3	3	0.44

C_{32}	1/2	1	2	2	0.25
C_{33}	1/3	1/2	1	3	0.19
C_{34}	1/3	1/2	1/3	1	0.12

λ_{max} = 4.16 ,RI=0.9,*CI*=0.05,*CR*=0.05＜0.1.

Step6: Assign weights to other factors, as shown in Table 7.

Table 7. Judgment matrix of other factors C4-C4ji.

Z	C_{41}	C_{42}	C_{43}	C_{44}	ω_i
C_{41}	1	5	3	7	0.56
C_{42}	1/5	1	1/3	3	0.12
C_{43}	1/3	3	1	5	0.26
C_{44}	1/7	1/3	1/5	1	0.06

λ_{max} = 4.11 ,RI=0.9,*CI*=0.04,*CR*=0.04＜0.1.

Step7: Index comprehensive weight.

Multiply the weights of the index layer and the corresponding criterion layer to obtain the comprehensive weights of each index in the criterion layer, as shown in Table 8.

Table 8. Comprehensive weights of indicators.

Serial number	index	Comprehensive weight	Serial number	index	Comprehensive weight
1	C_{11}	0.27	9	C_{22}	0.04
2	C_{12}	0.16	10	C_{32}	0.03
3	C_{13}	0.12	11	C_{24}	0.02
4	C_{21}	0.08	12	C_{33}	0.02
5	C_{14}	0.07	13	C_{34}	0.01
6	C_{23}	0.07	14	C_{42}	0.01
7	C_{41}	0.06	15	C_{43}	0.01
8	C_{31}	0.05	16	C_{44}	0.003

Step8: Entropy value method to determine the weight coefficient[13].

According to the calculation, the entropy weight matrix is ω_i = (0.050 3,0.058 4,0.061 7,0.0420,0.025 1,0.039 7,0.038 0,0.031 5,0.028 4,0.036 7,0.048 1,0.086 1,0.094 8,0.086 2,0.047 0,0.072 7).

Step9: Calculated proximity.

Through calculation ρ_{Hi} =(0.243,0.720,0.454,0.025,-0.012).

Among them, the membership degree of "general" is the largest, which is 0.720. Therefore, it can be concluded that the comprehensive evaluation result of postgraduate academic ethics is good. This conclusion is basically consistent with the results of interviews with graduate tutors.

5 Summarize and optimize the countermeasures for the construction of postgraduate academic ethics and style of study

This paper proposes an assessment and evaluation method based on a fuzzy matter-element model for graduate students' academic ethics and academic style construction. In this method, the influencing factors of graduate students' academic ethics and academic style construction were identified using a fishbone analysis chart. Subsequently, an assessment and evaluation index system was developed, and the index weights were determined through fuzzy matter-element analysis and the AHP method. This method minimizes all uncertainties and eliminates incompatibilities between indicators. In recent years, in the process of nurturing talents, it is essential not only to impart professional and technical knowledge but also to instill correct values and integrity in students. However, the issue of academic ethics still persists, negatively impacting the academic environment and the development of talent.

Firstly, an academic integrity system should be established to standardize the academic punishment process. Widely establish academic credibility across all levels of social governance, and achieve the legalization and institutionalization of academic ethics. Secondly, we should cultivate a positive social atmosphere and promote good values. Colleges and universities should cultivate a rigorous academic environment that shapes students' thinking. Finally, graduate students should enhance their moral character and improve their personal academic literacy. The cultivation of academic ethics depends largely on the efforts of graduate students themselves, which includes building a strong foundation of professional knowledge and scientific methods.

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