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A Fuzzy Comprehensive Evaluation Model for Ideological and Political Education in Mathematics Courses of Applied Undergraduate Institutions

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Abstract: To improve the scientific and practical evaluation of ideological and political education in mathematics courses at applied undergraduate universities, this paper constructs a systematic evaluation system for ideological and political education demonstration courses based on a fuzzy comprehensive evaluation model. By constructing a multi-level indicator system and introducing expert weighting and membership functions, this system achieves a quantitative evaluation of the teaching process and educational outcomes. The model is applied and analyzed using empirical data from courses such as "Advanced Mathematics" at a certain university. The results demonstrate that the model has good accuracy and adaptability in identifying the effectiveness of ideological and political education in courses and distinguishing between different teachers' teaching performances. This model can provide theoretical support and practical reference for the evaluation and improvement of ideological and political education in universities.

1. Introduction

Guided by the fundamental mission of cultivating morality and educating people in universities in the new era, ideological and political education in courses has become a key direction for higher education reform in my country [1]. Mathematics, a foundational and instrumental course, has long emphasized knowledge over values in terms of value guidance and ideological education[2]. Integrating ideological and political elements into mathematics classes not only helps improve students' overall literacy but also fosters a synergistic integration of knowledge transfer and value guidance [3]. Scientifically assessing the degree to which this "ideological and political education" goal is achieved in mathematics courses has become a critical issue that needs to be addressed in the current education evaluation system [4].

However, the evaluation targets for ideological and political education in courses are mostly "soft

indicators," such as teacher guidance ability, changes in student values, and the penetration of the teaching process [5]. Traditional quantitative evaluation methods fail to fully and accurately reflect their actual effectiveness [6]. Fuzzy Comprehensive Evaluation (FCE), based on fuzzy mathematics theory, effectively handles multi-factor, multi-level, and fuzzy evaluation problems [7]. It has been widely applied in fields such as education quality, talent development, and project management [8]. Therefore, building an ideological and political education evaluation system using the FCE model is an important path to quantifying and improving teaching quality [9].

This paper examines mathematics courses in applied undergraduate universities and constructs a scientific evaluation system for ideological and political education demonstration courses based on the FCE model. By setting multidimensional indicators, constructing an evaluation matrix, and calculating comprehensive membership, this system quantitatively evaluates the effectiveness of ideological and political education teaching. Furthermore, empirical analysis is conducted on actual courses. The results can provide a quantitative basis and improvement direction for the development of ideological and political education in mathematics courses in universities, and have certain theoretical significance and promotional value.

2. Related work

In recent years, with the deepening advancement of ideological and political education in courses, many universities have begun exploring how to integrate value-oriented education into professional course teaching, particularly in mathematics courses [10]. Existing research has generally focused on reconstructing course content, reforming teaching methods, and improving teacher capabilities [11]. Some universities have attempted to enhance the educational function of mathematics courses through case studies and classroom discussions [12]. For example, some scholars have proposed that "using mathematical problems to guide students' reflection on social responsibility" is one of the key approaches to achieving ideological and political integration. However, this research has largely focused on summarizing teaching practices and lacks systematic quantitative evaluation methods to support it [13].

In the field of educational evaluation, fuzzy comprehensive evaluation (FCE), due to its adaptability to fuzziness and uncertainty, has been widely used in evaluation systems covering multiple dimensions, including teacher teaching quality, course teaching effectiveness, and student overall quality [14]. The FCE model boasts a clear structure, controllable computations, and adaptability to multi-dimensional indicators. It can effectively integrate multi-source evaluation information, including expert opinions and student feedback, and output quantitative results. Fuzzy comprehensive evaluation demonstrates strong practicality and scientific validity, particularly when evaluating educational objectives that are difficult to measure directly [15].

Although existing research has used the FCE model in educational evaluation, research specifically evaluating ideological and political education in courses, particularly in mathematics, remains relatively scarce. Currently, there is a lack of a systematic evaluation framework and unified indicator system for the effectiveness of ideological and political education in mathematics courses, making it difficult to compare and continuously improve outcomes across courses and disciplines. Therefore, constructing an evaluation model for ideological and political education in mathematics courses based on fuzzy comprehensive evaluation not only fills this theoretical gap but also provides practical data support and decision-making basis for university administrators.

3. Evaluation model construction and system design

3.1. Construction of evaluation index system

To scientifically evaluate the effectiveness of ideological and political education in mathematics courses, a rationally structured and clearly structured evaluation indicator system is necessary. Based on literature research and expert interviews, this article divides the evaluation system into three levels: the target level (A), the criterion level (B), and the indicator level (C). The target level is the "comprehensive evaluation of ideological and political education in courses," while the criterion level includes five first-level indicators: curriculum design (B1), teaching process (B2), integration of ideological and political elements (B3), learning outcomes (B4), and student feedback (B5). Each indicator is further subdivided into several second-level indicators. As shown in Figure 1.

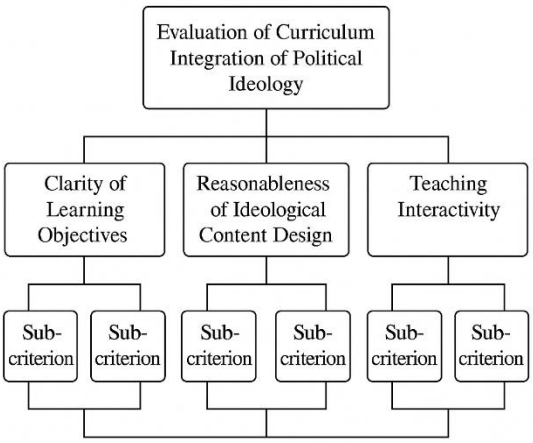

Figure 1: Hierarchical Structure of the Evaluation System

3.2. Determination of Weights

The weight of each evaluation indicator reflects its relative importance within the overall assessment system. In this study, a combination of expert scoring and the Analytic Hierarchy Process (AHP) is adopted to determine the weights at each level. First, a judgment matrix is constructed based on expert comparisons of the relative importance of indicators. Then, the consistency of the matrix is tested to ensure the rationality of the results. Finally, normalized weights are obtained for each criterion. For example, the weights of the five first-level indicators are set as follows:

$$W = (0.20, 0.25, 0.25, 0.15, 0.15) \tag{1}$$

These represent the weights assigned respectively to Curriculum Design, Teaching Process, Integration of Ideological Elements, Learning Effectiveness, and Student Feedback. Each set of sub-indicators under these main categories is also assigned a corresponding weight vector based on their relative importance. It is required that the sum of the weights for any set of indicators satisfies the following condition:

$$\sum_{i=1}^{n} w_i = 1 \tag{2}$$

This ensures that the evaluation system remains logically consistent and computationally valid.

3.3. Design of Membership Functions

To transform qualitative evaluation indicators into quantitative expressions, it is necessary to establish membership functions that reflect the degree of association between each evaluation indicator and the predefined evaluation levels. In this study, five evaluation levels are defined: Excellent, Good, Medium, Fair, and Poor, denoted as:

$$V = \{v_1, v_2, v_3, v_4, v_5\} \tag{3}$$

For indicators with a high degree of subjectivity, triangular or trapezoidal membership functions are commonly adopted. These functions enable the transformation of linguistic assessments into numerical values within the interval [0, 1], thereby allowing for fuzzy computation. Taking "Teaching Interactivity" as an example, a triangular membership function can be constructed to describe the affiliation degree of a certain indicator value x to a specific evaluation level. The function is defined as:

$$\mu_{ij} = \frac{x-a}{b-a} \quad (a \le x \le b) \tag{4}$$

As shown in Figure 2, the five-level fuzzy membership function diagram.

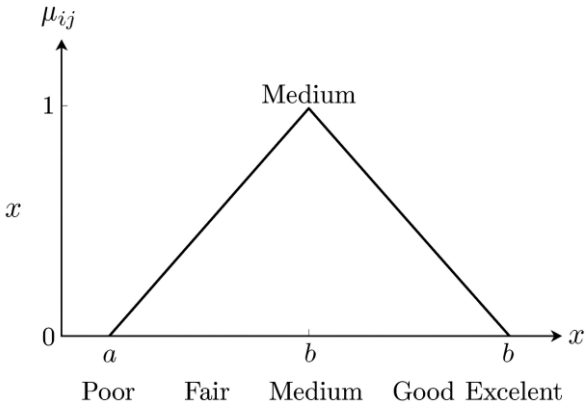

Figure 2: Five-level fuzzy membership function diagram

3.4. Fuzzy Comprehensive Evaluation and Output

After the evaluation indicators, weight vectors, and membership functions have been defined, a fuzzy comprehensive evaluation can be carried out. First, for each criterion, a fuzzy evaluation matrix R is constructed based on expert scoring or questionnaire data. Each row of R represents an indicator, and each column corresponds to a membership degree with respect to a particular evaluation level.

An example of a fuzzy evaluation matrix is:

$$R = \begin{bmatrix} 0.1 & 0.3 & 0.4 & 0.1 & 0.1 \\ 0.2 & 0.4 & 0.3 & 0.1 & 0.0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} \tag{5}$$

Next, the comprehensive evaluation vector B is obtained by performing a fuzzy synthesis operation using the weight vector W:

$$B = W \cdot R = (b_1, b_2, b_3, b_4, b_5) \tag{6}$$

Each element b_i in vector B represents the degree to which the evaluated object belongs to the corresponding evaluation level. To further quantify the result, a final score can be calculated using a weighted average method, where s_i denotes the score assigned to each evaluation level:

$$Score = \sum_{i=1}^{5} b_i \cdot s_i \tag{7}$$

3.5. Overall Process of the Evaluation Model

To ensure the logical integrity and practical operability of the fuzzy comprehensive evaluation system, this study designs a complete workflow for the assessment of ideological and political elements integrated into mathematics courses. The entire model process includes four main stages, as shown in Figure 3:

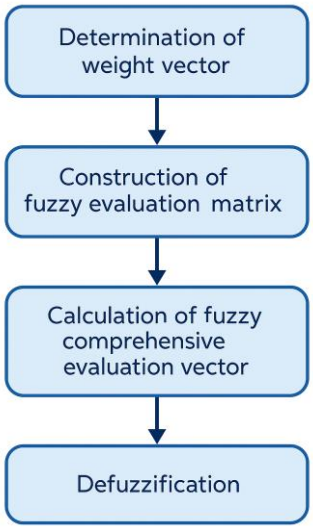

Figure 3: Overall flow chart

4. Empirical research and results analysis

4.1. Empirical Background and Data Sources

Table 1: Evaluation Data Samples

Sample ID	Student Feedback	Teaching Supervision Score	Teacher Self-Evaluation	Expert Group Score
S1	92.0	68.1	84.5	85.1
S2	76.2	83.4	75.1	93.5
S3	83.7	69.6	82.6	76.4
S4	78.2	86.2	75.0	92.3
S5	80.4	86.7	89.0	84.3
S6	86.3	78.1	90.1	90.1
S7	80.6	82.1	89.2	85.3
S8	93.3	86.8	80.1	87.7
S9	79.5	79.9	89.8	94.9
S10	84.3	88.4	82.3	84.3

In order to verify the applicability and effectiveness of the fuzzy comprehensive evaluation model constructed in this paper, the "Advanced Mathematics" course in the first semester of the 2024-2025 academic year of an applied undergraduate college was selected as the research object. This course is a compulsory course covering more than 200 students, and the teaching team has carried out multiple rounds of ideological and political reform practices in the course. The main sources of data include: student feedback questionnaires, teaching supervision evaluation records, self-evaluation of teaching teachers, expert group scores, etc. Finally, 50 complete comprehensive evaluation samples were selected for analysis. As shown in Table 1.

4.2. Model input and calculation process

Based on the indicator system and weight configuration established in Chapter 3, the original data were first normalized. Using the five-level evaluation scale (Excellent, Good, Medium, Fair, and Poor), a fuzzy evaluation matrix R was constructed. Each indicator's membership degree was calculated using triangular membership functions. The comprehensive evaluation results were then derived through the following fuzzy operation formulas:

$$B = W \cdot R \tag{8}$$

$$Score = \sum_{i=1}^{5} b_i \cdot s_i \tag{9}$$

This method yields a numerical value that reflects the overall quality of ideological and political integration in a given course sample, allowing for further quantitative comparisons and targeted instructional improvements.

4.3. Results presentation and analysis

The model calculated that the overall course scores ranged from 78 to 92, with a mean of 85.4, indicating a strong integration of ideological and political education into the model course. The highest-scoring students performed particularly well in the dimensions of "teaching interactivity" and "rational content design," while those with lower scores generally showed deficiencies in "student feedback satisfaction."

To more intuitively display the sample evaluation results, the following is drawn as shown in Figure 4:

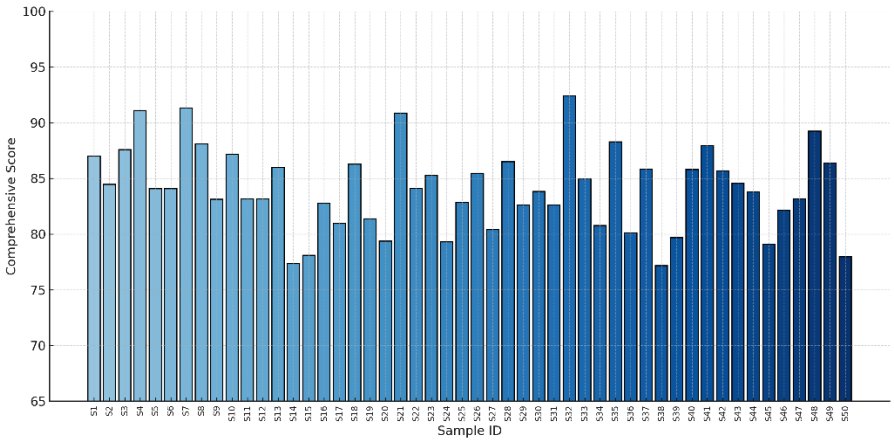

Figure 4: Distribution of comprehensive scores of ideological and political courses for 50 samples

4.4. Summary

Empirical analysis shows that the fuzzy comprehensive evaluation model can reflect the effectiveness of ideological and political education in courses in a relatively scientific and systematic manner. Its quantitative results can be used in multiple aspects, such as curriculum improvement, teaching management decision-making, and teacher development feedback, and has good application value and promotion potential.

5. Model application extension and comparative analysis

5.1. Feasibility analysis of cross-curricular applications

After evaluating the effectiveness of ideological and political education in the "Advanced Mathematics" course, this article further applied the constructed fuzzy comprehensive evaluation model to two other mathematics courses in the same college: "Linear Algebra" and "Probability Theory and Mathematical Statistics." As shown in Figure 5, using the same indicator system and evaluation process, data samples were collected and comprehensive calculations were performed. Significant differences were found among the three courses in terms of "Course Design" and "Ideological and Political Content Penetration." "Linear Algebra" scored relatively low in terms of the natural integration of ideological and political elements, suggesting that the logical connection between the course's teaching content and its value orientation needs to be strengthened.

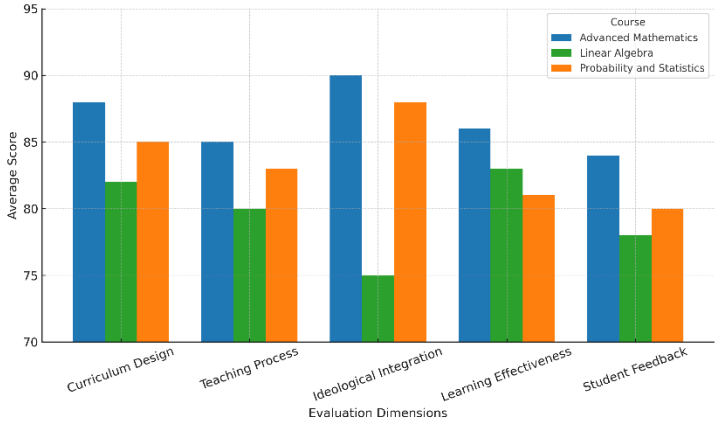

Figure 5: Comparison of the average scores of different courses on the five first-level indicators

5.2. Comparative Analysis of Teaching Evaluations of Different Teachers

To further validate the model's sensitivity and discriminatory power, this paper conducted a comparative analysis of teaching samples from three different instructors of the same course (Advanced Mathematics). The results, as shown in Figure 6, show significant differences in the scores of different instructors on the dimensions of "teaching interactivity" and "student feedback satisfaction," but relatively little difference in the dimension of "course design." This suggests that the model not only reflects the overall level of ideological and political development in the course, but also reflects individual differences in specific aspects of teaching execution.

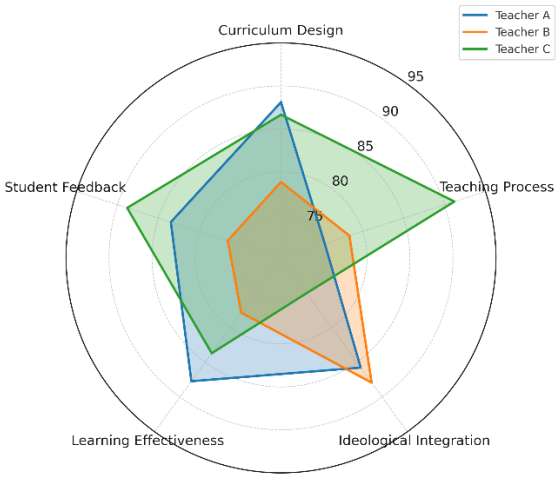

Figure 6: Scores of different teachers on each evaluation dimension

5.3. Comparison of model effects with traditional evaluation methods

To validate the advantages of this model, this paper introduced the traditional average scoring method as a reference and conducted a parallel evaluation on the same sample. The results, as shown in Figure 7, show that the traditional method suffers from a lack of differentiation in high-scoring samples. However, the fuzzy comprehensive evaluation model, through weight adjustment and membership calculation, can present a more nuanced evaluation hierarchy. The FCE model demonstrates particularly high discriminatory power for subjective indicators (such as ideological and political guidance expression).

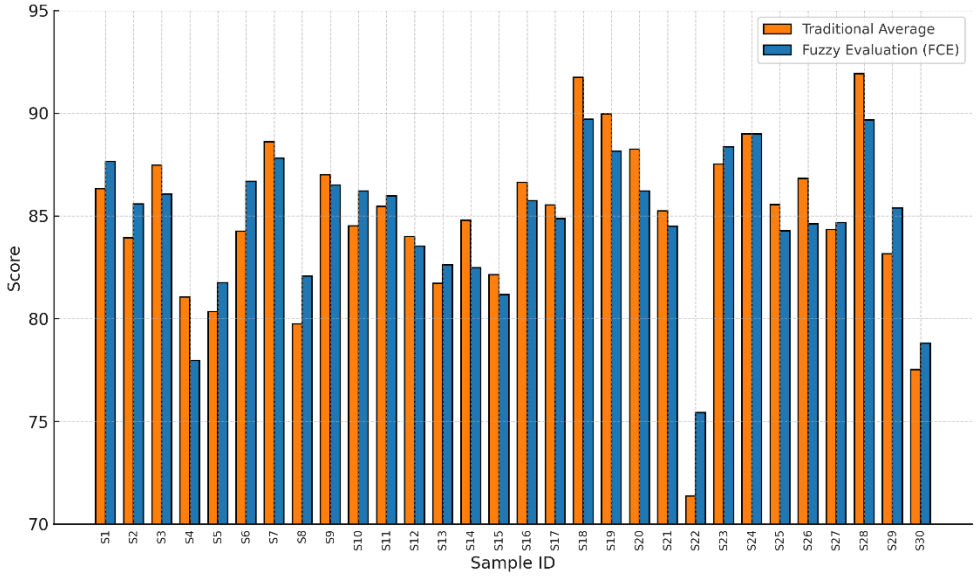

Figure 7: Comparison chart of FCE model and traditional average scoring method

6. Conclusion

This paper focuses on the evaluation of ideological and political education in mathematics courses at applied undergraduate universities. Based on a fuzzy comprehensive evaluation model, it constructs a systematic course evaluation system and verifies its applicability and effectiveness

through empirical data. This model fully considers the multidimensionality and subjectivity of evaluation indicators. Through membership functions and comprehensive calculations, it scientifically quantifies the effectiveness of ideological and political education in courses, addressing the shortcomings of traditional evaluation methods in terms of detail and discrimination.

Through practical application analysis of courses such as Advanced Mathematics, Linear Algebra, and Probability Theory and Mathematical Statistics, the model's generalization capabilities across multiple courses and teachers were verified. Further comparison with the traditional average scoring method revealed that the fuzzy comprehensive evaluation model has significant advantages in identifying boundary samples and uncovering potential problems, providing a more valuable reference for education administrators.

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