International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18 (2026) pp. 1–14

https://doi.org/10.70917/ijcisim-2026-0214
Article

Quantitative analysis of business English civic education: construction of an evaluation model based on fuzzy theory

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Abstract: In order to accurately measure the effect of Business English Civic and Political Education, this paper constructs a corresponding evaluation index system. The Fermatean fuzzy set of indicator data is established to calculate the uncertainty of evaluation indicator data. At the same time, through the sorting function and Zhenyuan integral operator, the relationship between the index attributes is judged to improve the accuracy of the evaluation indexes. In the fuzzy evaluation stage, the factor set and factor subset are established, the classification weights are calculated according to the indicator level, and the weight matrix is composed to judge the evaluation results. Hierarchical analysis and weight consistency test are introduced to complete the reasonable adjustment of weights and reduce the quantitative analysis error rate. In the evaluation index system of the effect of business English civic education, the highest weight is political quality, which reaches 0.4781. The weight consistency test is less than 0.1000. The subordination degree of the first and second level of the comprehensive rating of the civic teachers is more than 0.05, which is at a good level. Through fuzzy evaluation, the level of Business English Civics education can be judged intuitively.

Keywords: civic education; fuzzy evaluation; weight matrix; hierarchical analysis; Business English

1. Introduction

In the context of the development of the new era, the concept of talent cultivation emphasizes on communion, moral education, and integration and innovation, which makes the course ideology and politics be put forward; and it is also proposed in the guiding document of the construction of the course ideology and politics in colleges and universities that colleges and universities should promote the construction of the course ideology and politics in colleges and universities around the elements of moral education, talent cultivation, and value shaping [1-3].

Business English is the core course of Business English major. It aims to cultivate application-oriented talents, combining moral education and professional training, following the National Standards for Teaching Quality of Foreign Languages and Literatures, focusing on cultivating students' comprehensive application ability of Business English, especially the ability of listening, speaking, reading, writing and translating, so that students can skillfully use English to communicate effectively both orally and in writing in the future work and business interactions [4-6]. Curriculum Civics, is an important carrier to realize the goals of Business English teaching. In the process of learning language, culture and business, Business English majors are susceptible to the influence of foreign thoughts and cultures, discourse systems and ideologies, while the Civics and Politics of the Curriculum serves to inspire students to analyze the differences between Chinese and Western cultures and ideologies, and to promote students' thinking [7-9]. Integrating the elements of Civics and Politics into Business English teaching has far-reaching significance in cultivating composite talents with national sentiment, business knowledge and cross-cultural communication ability [10]. The current business English course Civics education in the Civics elements and business English is not enough adhesion, and the course evaluation method is only based on simple test papers and subjective reports, which is difficult to correctly and effectively reflect the effectiveness of the implementation of Civics in the course.

Evaluation based on fuzzy theory is based on fuzzy set theory, which blurs the concept of elements “belonging” to a set, and converts the determination of “either/or” into different affiliations of different elements to the same set [11]. The evaluation method of fuzzy theory in fuzzy mathematics is applied to the educational evaluation, the establishment of multiple evaluation subjects, quantitative and qualitative scientific transformation model, which can well solve this problem, and has been applied in a variety of educational evaluation, with good evaluation results [12-15].

The evaluation of the effect of Business English Civic Education involves multiple types of data and multi-dimensional judgments, and the evaluation indexes need to be strictly selected and processed during quantitative analysis to ensure the scientific nature of the evaluation. In this paper, before introducing the fuzzy theory to make a comprehensive evaluation of the effect of Civic and Political Education in Business English, the evaluation index system covering 3 first-level indicators and 12 second-level indicators is established. The quality of indicator selection is ensured by the uncertainty calculation of Fermatean fuzzy set, the ranking function and the judgment of weight attributes of Zhenyuan integral operator. After that, the hierarchical analysis method and weight consistency test are utilized to determine the weights of indicators and evaluation scores hierarchically, and the results of quantitative analysis of the effect of Business English Civic and Political Education are given comprehensively.

2. Design of Quantitative Analysis Method for Business English Civic Education

2.1. Design of Evaluation Indicator System for Civic and Political Education Effectiveness in Business English

In this paper, for the design and selection of evaluation indexes for the effect of business English Civic Education in colleges and universities, the indexes are designed as a two-tier index system based on the widely used Kirkpatrick's four-tier evaluation model. Table 1 shows the design and construction of the specific index system of business English civic and political education. Among them, the first-level index system includes three aspects of ideological quality, political quality and moral quality, and the second-level evaluation indexes total 12 aspects, including: learning attitude, self-discipline, practice awareness, values, political theory, political awareness, political position, political behavior, social morality, professional ethics, emotional character, and will quality.

Table 1. Evaluation Index System for Ideological and Political Education

Evaluation objective	Primary indicator	Primary indicator number	Secondary indicator	Secondary indicator number
Effectiveness of Ideological Education in Business English Teaching	Moral quality of thought	A1	Learning attitude	B1
			Self-discipline ability	B2
			Practice of consciousness	B3
	Political quality	A2	Values and Beliefs	B4
			Political theory	B5
			Political consciousness	B6
			Political stance	B7
			Political behavior	B8
	Moral quality	A3	Social morality	B9
			Professional Ethics	B10
			Emotional character	B11
			Moral character of will	B12

2.2. Quantitative analysis methods under fuzzy theory

2.2.1. Fermatean fuzzy sets

Definition 1: Let $X=\{x_1,x_2,\ldots,x_n\}$ be an argument domain, then the Fermatean fuzzy set (FFS) on X is defined as:

$$F=\{\langle x,\mu_F(x),v_F(x)\rangle,x\in I\} \tag{1}$$

where $\mu_F(x):X\to[0.0,1.0],v_F(x):X\to[0.0,1.0]$ denote the subordination and non-subordination functions of $x\in X$, respectively, and satisfy the condition $0.0\le\mu_F(x)^4+(v_F(x))^4\le1.0$. The exponent 4 here is the key property of Fermatean fuzzy sets, compared to the square restriction of Pythagorean fuzzy sets $(\mu_A(x)^2+v_A((x))^2\le1.0$, Fermatean fuzzy sets have a larger fuzzy set than traditional fuzzy sets, has a larger range of fuzziness expression. It can not only express the degree of subordination and non-subordination, but also flexibly express the uncertainty in the evaluation information. The degree of affiliation $\mu_A(x)$ and the degree of non-affiliation $v_A(x)$ do not take extreme values at the same time (e.g., $\mu_A(x)=1.0$ and $v_A(x)=1.0$ cannot happen at the same time), in order to ensure the consistency in the definition of the set. The degree of hesitancy or uncertainty is expressed as $\pi_F(x)=\sqrt[4]{1-(\mu_F(x))^4-(v_F(x))^4}$, which denotes the degree of uncertainty of the integrated evaluator about an element that reflects the incompleteness of the information. Generally, $F=(\mu_F,v_F)$ is referred to as a Fermatean fuzzy number (FFN).

Definition 2: Let $X=\{x_1,x_2,\ldots,x_n\}$ be a set, and the interval-valued Fermatean fuzzy set can be defined as

$$F=\left\{\left\langle X,\left[\mu_{F_L}(X),\mu_{F_U}(X)\right],\left[v_{F_L}(X),v_{F_U}(X)\right]\right\rangle \mid X\in I\right\} \tag{2}$$

where $X\to Int[0,1],x\in X;\mu_F(x)=\left[\mu_{F_L}(x),\mu_{F_U}(x)\right]$ is the degree of subordination of the element x belonging to the set F. $v_F(x)=\left[v_{F_L}(x),v_{F_U}(x)\right]\to Int[0,1]$ is the degree of non-affiliation of the element x belonging to the set F and satisfying that, for any $x\in X$, there is $0.0<\sup_x(\mu_F(x))^4+\sup_x(v_F(x))^4\le1.0$.

The degree of hesitancy or uncertainty is denoted as:

$$\pi_F(x)=\left[\pi_{F_L}(x),\pi_{F_U}(x)\right]=\left[\sqrt[4]{1-\left(\mu_{F_U}(x)\right)^4-\left(v_{F_U}(x)\right)^4},\sqrt[4]{1-\left(\mu_{F_L}(x)\right)^4-\left(v_{F_L}(x)\right)^4}\right] \tag{3}$$

If $F_i=\left\langle\left[\mu_{F_{iL}},\mu_{F_{iU}}\right],\left[v_{F_{iL}},v_{F_{iU}}\right]\right\rangle,i=1,2,3,4$ is three interval Fermatean fuzzy numbers, the operators between them are

1) $F_1\oplus F_2=\left(\left[\sqrt[3]{\mu_{F_{1L}}^3+\mu_{F_{2L}}^3-\mu_{F_{1L}}^3\mu_{F_{2L}}^3},\sqrt[3]{\mu_{F_{1U}}^3+\mu_{F_{2U}}^3-\mu_{F_{1U}}^3\mu_{F_{2U}}^3}\right],\left[v_{F_{1L}}v_{F_{2L}},v_{F_{1U}}v_{F_{2U}}\right]\right)$;

2) $F_1\otimes F_2=\left(\left[\mu_{F_{1L}}\mu_{F_{2L}},\mu_{F_{1U}}\mu_{F_{2U}}\right],\left[\sqrt[3]{v_{F_{1L}}^3+v_{F_{2L}}^3-v_{F_{1L}}^3v_{F_{2L}}^3},\sqrt[3]{v_{F_{1U}}^3+v_{F_{2U}}^3-v_{F_{1U}}^3v_{F_{2U}}^3}\right]\right)$;

3) $\lambda F=\left(\left[\sqrt[3]{1-\left(1-\mu_{F_L}^3\right)^\lambda},\sqrt[3]{\left(1-1-\mu_{F_U}^3\right)^\lambda}\right],\left[v_{F_L}^\lambda,v_{F_U}^\lambda\right]\right)$;

4) $F^\lambda=\left(\left[\mu_{F_L}^\lambda,\mu_{F_U}^\lambda\right],\left[\sqrt[3]{1-\left(1-v_{F_L}^3\right)^\lambda},\sqrt[3]{1-\left(1-v_{F_U}^3\right)^\lambda}\right]\right)$; and in addition to these;

5) $F_1\oplus F_2=F_2\oplus F_1$;

6) $F_1\otimes F_2=F_2\otimes F_1$;

7) $\lambda\left(F_1 \oplus F_2\right)=\lambda F_2 \oplus \lambda F_1, \lambda>0$;

8) $\left(F_1 \otimes F_2\right)^\lambda=F_2{}^\lambda \otimes F_1{}^\lambda, \lambda>0$;

9) $\lambda_1 \cdot F \oplus \lambda_2 \cdot F=\left(\lambda_1 \oplus \lambda_2\right) \cdot F, \lambda_1>0, \lambda_2>0$;

10) $F^{\lambda_1} \otimes F^{\lambda_2}=F^{\lambda_1+\lambda_2}, \lambda_1>0, \lambda_2>0$.

Definition 3: Let $F_i=\left\langle\left[\mu_{F_{iL}}, \mu_{F_{iU}}\right],\left[v_{F_{iL}}, v_{F_{iU}}\right]\right\rangle(i=1,2,\ldots,n)$ be a set of interval Fermatean fuzzy numbers, then the interval Fermatean fuzzy weighted average (IVFFWA) is:

$$
\begin{aligned}
& IVFFWA\left(F_1,\ldots,F_n\right)=\underset{i=1}{\overset{n}{\oplus}} \omega_i F_i=\omega_1 F_1 \oplus \omega_2 F_2 \oplus \ldots \oplus \omega_n F_n \\
& =\left(\left[\sqrt[4]{1-\prod_{i=1}^n\left(1-\mu_{F_{iL}}^4\right)^{\omega_i}}, \sqrt[4]{1-\prod_{i=1}^n\left(1-\mu_{F_{iU}}^4\right)^{\omega_i}}\right],\left[\prod_{i=1}^n\left(v_{F_{iL}}\right)^{\omega_i}, \prod_{i=1}^n\left(v_{F_{iU}}\right)^{\omega_i}\right]\right)
\end{aligned} \tag{4}
$$

where $\omega=\left(\omega_1, \omega_2, \cdots, \omega_n\right)^T$ is a weight vector satisfying $\omega_t \in[0,1], \sum_{t=1}^n \omega_t=1$.

Definition 4: Let $F_1=\left\langle\left[\mu_{F_{1L}}, \mu_{F_{1U}}\right],\left[v_{F_{1L}}, v_{F_{1U}}\right]\right\rangle, F_2=\left\langle\left[\mu_{F_{2L}}, \mu_{F_{2U}}\right],\left[v_{F_{2L}}, v_{F_{2U}}\right]\right\rangle$ are the two intervals of Fermatean fuzzy numbers, the F_1 and F_2 have a Euclidean distance of:

$$
D\left(F_1, F_2\right)=\frac{1}{4} \sqrt{\left(\begin{array}{c}
\left(\mu_{F_{1L}}^4-\mu_{F_{2L}}^4\right)^2+\left(\mu_{F_{1U}}^4-\mu_{F_{2U}}^4\right)^2+\left(v_{F_{1L}}^4-v_{F_{2L}}^4\right)^2+\left(v_{F_{1U}}^4-v_{F_{2U}}^4\right)^2 \\
+\left(\pi_{F_{1L}}^4-\pi_{F_{2L}}^4\right)^2+\left(\pi_{F_{1U}}^4-\pi_{F_{2U}}^4\right)^2
\end{array}\right)} \tag{5}
$$

2.2.2. Sorting functions

In the interval Fermatean fuzzy environment, the existing score function is as follows:

Definition 1: Let $F=\left\langle\left[\mu_{F_i}, \mu_{F_v}\right],\left[v_{F_i}, v_{F_v}\right]\right\rangle$ be the interval fuzzy number, then the score function of F is:

$$
S(F)=\left(\left(\mu_{F_L}\right)^4+\left(\mu_{F_U}\right)^4-\left(v_{F_L}\right)^4-\left(v_{F_U}\right)^4\right) \in[0.0,1.0] \tag{6}
$$

Definition 2: The accuracy function is defined as:

$$
H(F)=\frac{\mu_{F_L}^3+\mu_{F_U}^3+v_{F_L}^3+v_{F_U}^3}{2} \in[0,1] \tag{7}
$$

Then for any two intervals Fermatean fuzzy numbers F_1 and F_2 have:

1) If $S\left(F_1\right)>S\left(F_2\right)$, then $F_1>F_2$;

2) If $S\left(F_1\right)=S\left(F_2\right), H\left(F_1\right)>H\left(F_2\right)$, then $F_1>F_2$;

3) If $H\left(F_1\right)=H\left(F_2\right)$, then $F_1=F_2$.

2.2.3. Zhenyuan integral operators

Definition 1: Given a set of functions $\mu: F \rightarrow[0,+\infty)$ satisfying $\mu(\varnothing)=0, A \in F$, and a function $f: X \rightarrow[0,+\infty)$, the f on A with respect to the μ is Zhenyuan integral is denoted by the symbol $(W) \int_{(A)} \mathrm{d} \mu$, viz:

$$(W)\int_{(A)} f \mathrm{d}\mu = \sup\left\{ \sum_{j=1}^{k} \lambda_j \mu\left(E_j\right) | f \geq \sum_{j=1}^{k} \lambda_j \chi_{E_j} \right\} \tag{8}$$

$E_j \in \mathrm{F} \cap \mathrm{A} = \{E \cap A \mid E \in F\}, k \geq 0, \lambda_j \geq 0, j = 1, 2, \ldots, k, x$ denotes the eigenfunction, when X is finite, as in $X = \{x_1, x_2, \ldots, x_n\}$, and take its power set $P(X)$ to be F , then the upper certainty bound must be reached when the equation $f = \sum_{j=1}^{k} \lambda_j \chi_{E_j}$ holds, which can be simplified as:

$$(\mathrm{W})\int_{(A)} f \mathrm{d}\mu = \max\left\{ \sum_{j=1}^{2^n-1} \lambda_j \mu\left(E_j \cap A\right) | f = \sum_{j=1}^{2^n-1} \lambda_j \chi_{E_j \cap A} \right\} \tag{9}$$

Where λ_j can be $0 (j = 1, 2, \ldots, 2n-1)$ and satisfies $E_j = \left\{ x_i \mid \frac{j}{2^i} - \left[\frac{j}{2^i}\right] \geq \frac{1}{2}, 1 \leq i \leq n \right\} \subset X$, by applying the following algorithm, a very accurate integral value can be obtained.

Figure 1 shows the steps and flow of the algorithm:

1) Input $n, M = \left(\mu_1, \mu_2, \ldots, \mu_{2^n-1}\right)$, and $F = \left(f_1, f_2, \ldots, f_n\right), f_i = f\left(x_i\right), i = 1, 2, \ldots, n$;

2) Initialize $J = \left(j_1 = 2^0, j_2 = 2^1, \ldots, j_n = 2^{n-1}\right)$;

3) According to the matrix $E_j = e_{ij} = \begin{cases} 1 & \frac{j}{2^i} - \left[\frac{j}{2^i}\right] \geq \frac{1}{2} \\ 0 & else \end{cases}$;

4) Extract $B = \left(b_{ik}\right)_{n \times n}$ from matrix E according to the values of matrix J ;

5) Compute B^{-1} and $L^T = \lambda_j = \left(\lambda_{j1}, \lambda_{j2}, \ldots, \lambda_{jn}\right)^T = B^{-1} F^T$;

6) Compute $LM_J^{\mathrm{T}} = \sum_{k=1}^{n} \lambda_{j_k} \mu_{j_k}, M_J = \left(\mu_{j_1}, \mu_{j_2}, \ldots, \mu_{j_n}\right)$;

7) Let $C^{(j)} = \left(c_1^{(j)}, c_2^{(j)}, \ldots, c_n^{(j)}\right) = B^{-1} A^{(j)}$, where $A^{(j)} = \left(a_{1j}, a_{2j}, \ldots, a_{nj}\right)^{\mathrm{T}}$, finding $j \notin J$. For example $M_j C^{(j)} - \mu_j < 0$. If such a J does not exist, go to (9), otherwise, find such a j and all k such that $c_{(j)}^{k} > 0$, and then choose K_0 from it, e.g., $\lambda_{j_{k_0}} / c_{k_0}^{(j)} = \min \lambda_{j_k} / c_k^{(j)} \left(c_k^{(j)} > 0\right)$;

8) Replace j_{k0} with j in J and go to (4);

9) Output I, J, L ;

10) Stop.

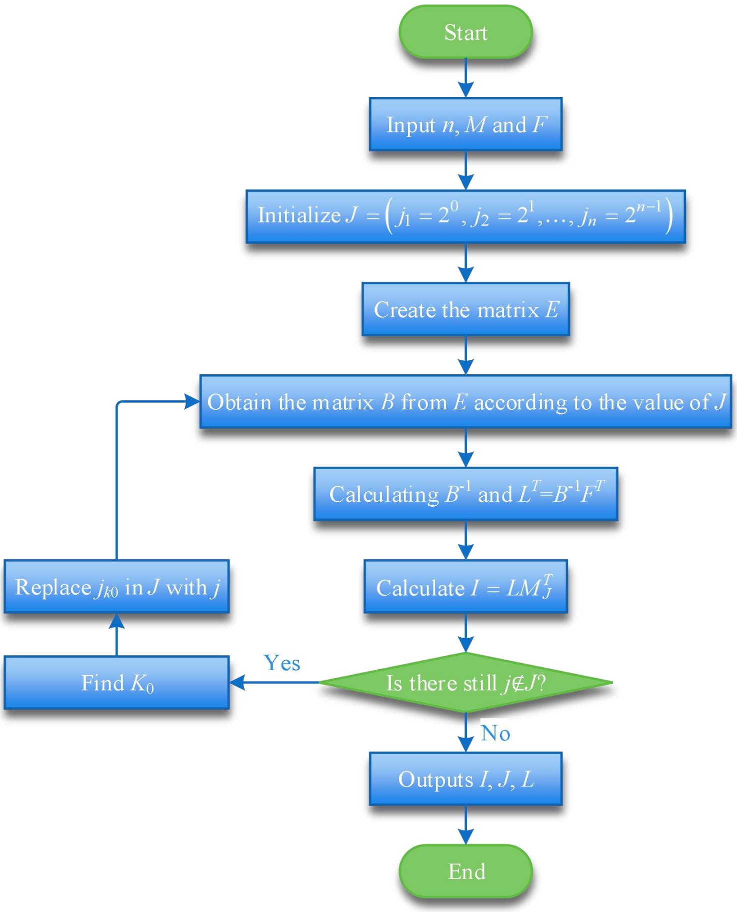

Figure 1. Algorithm flowchart

Definition 2: Fuzzy Measure Let $A(X)$ be the power set of $X = \{x_1, x_2, \ldots, x_n\}$, and given $\rho \in (-1, \infty)$, $\mu : A(X) \to [0,1]$ is said to be the power set of a fuzzy measure if it satisfies the following conditions μ is a fuzzy measure defined on X.

1) $\mu(\varnothing) = 0, \mu(X) = 1.0$;

2) If $B, C \in P(X)$, then we have $\mu(B) \le \mu(C)$;

3) $\forall B, C \in P(X), B \cap C = \varnothing, \mu(B \cup C) = \mu(B) + \mu(C) + \rho\mu(B)\mu(C)$;

If X is an indicator set for a multi-attribute comprehensive evaluation, then for $B, C \in P(X), \mu(B)$ and $\mu(C)$ can be considered as the weights of the attribute sets B and C. If $\rho = 0.0, \mu(B \cup C) = \mu(B) + \mu(C)$, then the attribute sets are shown to be independent of each other. If $-1.0 < \rho < 0.0, \mu(B \cup C) < \mu(B) + \mu(C)$, it indicates that the attribute sets are redundantly related to each other.

If $\rho > 0.0, \mu(B \cup C) > \mu(B) + \mu(C)$, it indicates a complementary association between the attributes.

2.3. Multi-level fuzzy comprehensive evaluation principle

2.3.1. Steps for integrated evaluation

After determining the attributes of indicators through Fermatean fuzzy set, ranking function, Zhenyuan integral operator, and improving the certainty of indicators, the corresponding quantitative indicators are completed to be determined. After that, the quantitative evaluation of the indicators of the effect of Business English Civic and Political Education usually adopts the multi-level evaluation system, and the general steps of the multi-level comprehensive evaluation (including the second-level indicator system as an example) are as follows:

1) According to the index evaluation system, determine the factor set and factor subset as:

$$\mathbf{U} = \left(\mathbf{U}_1 \quad \mathbf{U}_2 \quad \cdots \quad \mathbf{U}_s\right) \tag{10}$$

where $\mathbf{U}$ is the factor set, $\mathbf{U}_k = \left(u_{k1} \quad u_{k2} \quad \cdots \quad u_{km}\right)$, $(k = 1,2,\cdots,s)$ is the factor subset, s is the number of factor subsets, i.e., the number of level 1 indicators, and m is the number of level 2 indicators for the k th level 1 indicator.

2) Primary evaluation of each factor subset

First of all, according to the size of the role played by each factor in the subset of factors, determine the allocation of weights for the evaluation results:

$$\mathbf{A}_k = \left(a_{k1} \quad a_{k2} \quad \cdots \quad a_{km}\right) \tag{11}$$

Where $a_{kj}\,(j = 1,2,\cdots,m)$ is the weight of each secondary indicator in the k th subset of factors and satisfies $\sum_{j=1}^{m} a_{kj} = 1.0$.

Then, the single-factor evaluation matrix for the k th factor subset is composed based on the rating scale of each factor in the indicator system:

$$\mathbf{R}_k = \begin{pmatrix} r_{k11} & r_{k12} & \cdots & r_{k1n} \\ r_{k21} & r_{k22} & \cdots & r_{k2n} \\ \vdots & \vdots & & \vdots \\ r_{km1} & r_{km2} & \cdots & r_{kmn} \end{pmatrix} \tag{12}$$

where n is the number of rubric levels.

Finally, the primary evaluation results can be calculated by using the weighting matrix:

$$\mathbf{B}_k = \mathbf{A}_k \times \mathbf{R}_k = \left(b_{k1} \quad b_{k2} \quad \cdots \quad b_{kn}\right) \tag{13}$$

3) Comprehensive Evaluation

First, the subset of factors in the factor set is viewed as s single factors, and according to the magnitude of the role they play, the assigned weights $\mathbf{A}$ of the evaluation results are determined and expressed as follows:

$$\mathbf{A} = \left(a_1 \quad a_2 \quad \cdots \quad a_s\right) \tag{14}$$

where $a_i\,(i = 1,2,\cdots,s)$ is the assigned weight of the evaluation results of each factor subset and satisfies $\sum_{k=1}^{s} a_k = 1.0$.

Then, the total single-factor evaluation matrix is obtained according to the primary evaluation results:

$$\mathbf{R} = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & & \vdots \\ b_{s1} & b_{s2} & \cdots & b_{sn} \end{pmatrix} \tag{15}$$

The combined evaluation results are then calculated by weighting $\mathbf{A}$:

$$\mathbf{B} = \mathbf{A} \times \mathbf{R} = \left(b_1 \quad b_2 \quad \cdots \quad b_n\right) \tag{16}$$

Finally, a composite evaluation value is calculated:

$$y = \mathbf{B}\mathbf{T}^T \tag{17}$$

Where $\mathbf{T} = \begin{pmatrix} t_1 & t_2 & \cdots & t_n \end{pmatrix}$ is the score corresponding to each evaluation level.

This is the mathematical model of the second level of fuzzy comprehensive evaluation, if there are more levels of evaluation indicators, the subset of factors $\mathbf{U}_k$ can be further divided into the next level, using a similar method to get the fuzzy comprehensive evaluation mathematical model of the third level or more levels.

2.3.2. Assignment of factor set weights

The calculation results of the above mathematical model are highly related to the values assigned to the weights of the factor set, and different weight coefficients will lead to different evaluation results. The weights of the factor set are usually obtained using the hierarchical analysis method and are tested for consistency.

1) Hierarchical analysis method to determine the weights

Invite x experts to participate in the evaluation, each expert according to their own experience, two-by-two comparison of the degree of importance between the factors in the subset of factors, the number of indicators for the subset of factors m, need to go through the comparison of $m(m-1)/2$ times judgment. The comparison can build $m \times m$ scale matrix P_{ab}, where a, $b = 1, 2, \cdots, m$.

Denote the scale matrix obtained by the x-bit experts as $\mathbf{P}_{\mathrm{ab}}{}^k (h = 1, 2, \cdots, x)$, and compute the comparison judgment matrix for the subset of factors $\mathbf{U}_k$ as:

$$\mathbf{D}_k = \left(\prod_{h=1}^{x} \mathbf{P}_{ab}^h \right)^{\frac{1}{x}} \tag{18}$$

Calculate the eigenvalues of the comparison judgment matrix $\mathbf{D}_k$, and select the eigenvector corresponding to the largest eigenvalue $\lambda_{\max}^k$, which is normalized to obtain the weights of the indicators in the factor subset $\mathbf{U}_k$ on this layer $\mathbf{A}_k$.

For the first-level indicators, we can construct the comparison judgment matrix after $s(s-1)/2$ judgments as above, so as to get the weights of the first-level indicators on this level A.

2) Weight consistency test

Hierarchical analysis method to determine the weight of the evaluation of thinking will inevitably appear logical errors, so it is necessary to compare the judgment matrix $\mathbf{D}_k$ to do consistency test. The specific steps are as follows:

First, calculate the consistency index of the subset of factors $\mathbf{U}_k$:

$$CI_k = \frac{\lambda_{\max}^k - m}{m - 1} \tag{19}$$

Then calculate the consistency ratio of the subset of factors $\mathbf{U}_k$:

$$CR_k = \frac{CI_k}{RI_k} \tag{20}$$

where RI_k is the average random consistency indicator.

When the calculated consistency ratio is $CR_k < 0.1, (k = 1, 2, \cdots, s)$, the assignment of weights to the indicators in this factor subset on this layer is considered to satisfy the consistency requirement.

The consistency ratio of the whole comprehensive evaluation is:

$$CR = \frac{\sum_{k=1}^{s} CI_k a_k}{\sum_{k=1}^{s} RI_k a_k} \tag{21}$$

When the calculated $CR < 0.1000$, it is considered that the weight allocation of the whole evaluation also meets the consistency requirements.

When the above two consistency tests are satisfied, it is considered that the weight allocation in the evaluation index system is reasonable and can be used for evaluation decision-making, otherwise it is necessary to adjust the comparison judgment matrix $\mathbf{D}_k$ corresponding to the subset of factors with larger consistency indexes until it passes the consistency test.

3. Quantitative Analysis Practice of Business English Civic Education Based on Fuzzy Theory

3.1. Allocation of indicator weights

3.1.1. Data collection and factor set construction

Before using the hierarchical analysis method to obtain the weights of each indicator of the factor set, data on the evaluation of the educational effect of the Civics and Political Science class of the first-year students of Business English majors of A university on the grade were collected through a questionnaire. After that, the judgment matrix was constructed to finalize the weight situation of each indicator. A total of 120 questionnaires were distributed, 115 questionnaires were recovered, and after excluding invalid questionnaires, there were 110 valid questionnaires. Table 2 collects the results of the questionnaire on the evaluation of the effectiveness of business English first-year students on the Civic and Political Education. Using the hierarchical analysis method 1-9 scale, 2, 4, 6, 8 are the intermediate values of the judgment of two neighboring factors, 1, 3, 5, 7, 9 with the increase of the value, on behalf of the factor i is more important than the factor j incrementally. The target-level judgment matrix of the effect of Business English Civic Education is developed from four dimensions: students' mastery of professional knowledge, mastery of Civic knowledge, teachers' teaching practice and reflection ability, and curriculum construction. Based on the survey results to establish the judgment matrix of the goal level, and it can be seen from the survey results that the mastery of students' professional knowledge and the mastery of Civic and Political knowledge are the most important among the four goal level dimensions.

Table 2. Results of questionnaire survey on ideological and political education

	Proficient mastery of professional knowledge	**Knowledge of ideological and political education**	**Teachers' teaching practice and reflection ability**	**Course Construction**
Proficient mastery of professional knowledge	1	5	1	2
Knowledge of ideological and political education	5	1	1	1
Teachers' teaching practice and reflection ability	1	3	1	1
Course Construction	2	3		1

The mastery of professional knowledge and the mastery of civic and political knowledge, which is the concern of the first and second level indicators in the constructed indicator system, is constructed according to the survey results, and the judgment matrix of the first level and second level indicators is constructed at the guideline level. Table 3 shows the results of the survey on primary indicators. Table 4 shows the findings of the secondary indicators. In the survey results, it can be seen that the scale of ideological quality and political quality are both 5, which is higher compared to moral quality 3. And among the secondary indicators, the scales of political theory, political awareness, political position, and political behavior are concentrated in 3, 5, and 7, which are higher compared to the other 8 secondary indicators. It can also therefore be hypothesized that the weight value of the indicators related to political quality will be higher in the weight distribution of the indicators.

Table 3. Survey results of the first-level indicators

	Moral quality	**Political quality**	**Cognitive quality**
Moral quality	1	5	3
Political quality	5	1	3
Cognitive quality	3	3	1

Table 4. The results of the secondary indicator survey

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**
B1	1	1	3	3	5	5	7	5	3	5	1	1
B2	1	1	3	5	3	3	5	5	1	3	1	1
B3	3	3	1	1	3	3	3	3	1	3	1	1
B4	3	5	1	1	5	5	7	5	3	7	1	3
B5	5	3	3	5	1	3	3	3	1	3	1	1
B6	5	3	3	5	3	1	5	5	1	3	1	3
B7	7	5	3	7	3	5	1	7	1	1	1	1
B8	5	5	3	5	3	5	7	1	3	3	1	1
B9	3	1	1	3	1	1	1	3	1	1	1	1
B10	5	3	3	7	3	3	1	3	1	1	1	1
B11	1	1	1	1	1	1	1	1	1	1	1	1
B12	1	1	1	3	1	3	1	1	1	1	1	1

3.1.2. Weighting results

After constructing the judgment matrix, the root of the fourth power of the product of the elements of each row of the judgment matrix is calculated, after which the weights of each dimension are calculated and normalized to obtain the total weight result. Table 5 shows the results of the constructed factor set weights. Political quality (A2) has the highest weight in the first-level index of evaluating the effect of business English civic education, reaching 0.4781, followed by ideological quality (A1) 0.3526. In the second-level index, the highest weights are political awareness (B6) 0.1279, political standpoint (B7) 0.1252, and political theory (B5) 0.1193; and the lowest weights are affective character (B11) 0.0193.The fuzzy evaluation model of Business English Civic and Political Education is constructed from the total index weights.

Table 5. Factor set weight results

Target layer	**Criterion Layer**	**Criterion weight**	**Indicator Layer**	**Indicator weight**
Effectiveness of Ideological Education in Business English Teaching	A1	0.3526	B1	0.0802
			B2	0.0700
			B3	0.0989
			B4	0.1035
	A2	0.4781	B5	0.1193
			B6	0.1279
			B7	0.1252
			B8	0.1057
	A3	0.1693	B9	0.0521
			B10	0.0637
			B11	0.0193
			B12	0.0342

3.2. Weight consistency test and evaluation statistics

3.2.1. Weight consistency test

In order to reduce the logical errors that may occur in the hierarchical analysis method of judging the weights, five experts in the field of ideology and political education were invited to conduct consistency tests on the weights of the indicators in the factor set. Table 6 shows the weights of the indicators and the consistency test results. The consistency indicator CRs of the corresponding secondary indicators under each level one indicator are 0.0086, 0.0079, 0.0082, which are all greater than 0.0070 and less than 0.1000, indicating that the allocation of the indicator weight coefficients is effective and reasonable, and the consistency test of the weights passes.

Table 6. The weights of each indicator and the results of consistency test

Evaluation indicators	Indicator weight	λ_{max}	CR
B1-B4	(0.0802,0.0700,0.0989,0.1035)	5.3093	0.0086
B5-B8	(0.1193,0.1279,0.1252,0.1057)	5.0184	0.0079
B9-B10	(0.0521,0.0637,0.0193,0.0342)	5.5277	0.0082

3.2.2. Student Body Evaluation Statistics

The collected data on the evaluation of the effectiveness of Business English Civics Education were normalized to obtain the affiliation value of each evaluation factor, and to determine the students' evaluation of the Business English Civics Education instructors. Table 7 shows the statistical values of students' subject evaluation. In the evaluation data of the first-year business English students for the Civics teachers of this year, it can be seen that the percentage of “excellent” is between 0.71-0.91, which is higher than the evaluation data of good, medium and qualified. It shows that students' evaluation of the teacher's Civics education is good, but there is still room for improvement in specific indicators.

Table 7. Student-based evaluation statistics values

first-level indicator	second-level indicator	Evaluation Set (Percentage of Total Number)			
		Excellent	Good	Medium	Qualified
A1	B1	0.84	0.05	0.10	0.01
	B2	0.79	0.20	0.01	0.00
	B3	0.81	0.12	0.04	0.03
	B4	0.74	0.18	0.06	0.02
A2	B5	0.91	0.09	0.00	0.00
	B6	0.83	0.10	0.03	0.04
	B7	0.76	0.14	0.05	0.05
	B8	0.71	0.18	0.07	0.04
A3	B9	0.84	0.16	0.00	0.00
	B10	0.82	0.15	0.03	0.00
	B11	0.76	0.21	0.02	0.01
	B12	0.78	0.18	0.04	0.00

3.3. Calculation of Evaluation Results of Civic Education

3.3.1. First-level evaluations

Evaluate the course effect of Teacher 1 of Business English Civics Education from the first level index. Substitute the weights A1, A2 and A3 calculated from the hierarchical analysis into the calculation formula to find out B_{A1}, B_{A2} and B_{A3} of the effect of Business English Civics Education of

Teacher 1. $B_{A1}=A1*R_{1/2/3/4}=0.3526*\begin{pmatrix} 0.84 & 0.05 & 0.10 & 0.01 \\ 0.79 & 0.20 & 0.01 & 0.00 \\ 0.81 & 0.12 & 0.04 & 0.03 \\ 0.74 & 0.18 & 0.06 & 0.02 \end{pmatrix} = (0.2962, 0.0176, 0.0353, 0.0035)$, according to the principle of maximum affiliation, the affiliation value of the A1 indicator of the effect of Business English Civics Education of Teacher 1 is 0.2962. $B_{A2}=A2*R_{5/6/7/8} = 0.4781*\begin{pmatrix} 0.91 & 0.09 & 0.00 & 0.00 \\ 0.83 & 0.10 & 0.03 & 0.04 \\ 0.76 & 0.14 & 0.05 & 0.05 \\ 0.71 & 0.18 & 0.06 & 0.04 \end{pmatrix} = (0.4351, 0.0430, 0.0000, 0.0000)$, according to the principle of maximum affiliation, the affiliation value of A2 indicator of the effectiveness of business English civics education of Teacher 1 is 0.4351. $B_{A3} = A3*R_{9/10/11/12} = 0.1693*\begin{pmatrix} 0.84 & 0.16 & 0.03 & 0.00 \\ 0.82 & 0.15 & 0.03 & 0.00 \\ 0.76 & 0.21 & 0.02 & 0.01 \\ 0.78 & 0.18 & 0.04 & 0.00 \end{pmatrix} = (0.1422, 0.0271, 0.0051, 0.0000)$, according to the principle of maximum affiliation, the affiliation value of A3 indicator of the effectiveness of business English civics education of Teacher 1 is 0.1422. Business English Civic and Political Education Effectiveness Level 1 indicators were assigned, resulting in Teacher 1's Level 1 evaluation scores of 75.43 (good), 89.75 (excellent), and 60.48 (passing).

3.3.2. Secondary evaluation

Evaluate the course effect of Business English Civic Education Teacher 1 from the second-level indicators. Similarly, the weights of each second-level indicator calculated by hierarchical analysis are substituted into the calculation formula to find out the score of Teacher 1 in the evaluation of second-level indicators respectively. The affiliation degree of Teacher 1 in the second-level index B1 is $y_{B1}=B1*R_1=0.0802*(0.85, 0.05, 0.10, 0.01) = (0.0674, 0.0040, 0.0080, 0.0008)$. According to the principle of maximum affiliation, the evaluation affiliation value of Teacher 1's Business English Civic and Political Education Effectiveness in the second-level indicator B1 is 0.0674. Similarly, the maximum affiliation of B2-B12 is calculated as 0.0553, 0.0801, 0.0766, 0.1086, 0.1061, 0.0951, 0.0750, 0.0438, 0.0522, 0.0147, 0.0267. After assigning values to the degree of affiliation, the teacher scored high on the four relevant secondary indicators of political quality.

3.3.3. Comprehensive evaluation

Based on the results obtained from the first level fuzzy evaluation and the results obtained from the second level fuzzy evaluation, a fuzzy evaluation matrix was established. The final calculation obtained the comprehensive score of this teacher 1 in Business English Civic Education is $T=(0.2962, 0.4351, 0.1422)*(0.0674, 0.0553, 0.0801, 0.0766, 0.1086, 0.1061, 0.0951, 0.0750, 0.0438, 0.0522, 0.0147, 0.0267)$, and the final T=0.0554. The comprehensive score affiliation degree is greater than 0.05, and the effect of this teacher's Business English Civic Education is at a good level.

Figure 2 shows the comprehensive cloud evaluation results of the index scores of Teacher 1 in the fuzzy model. The higher the degree of affiliation, the better the effect of the teacher's Civic and Political Education on this indicator is proved. The affiliation degree of 0.4351 for the first-level indicator of political quality (A2) and the affiliation degrees of 0.1086, 0.1061, 0.0951, 0.0750 for the second-level indicators B5-B8 are all at a high level. The effect of this teacher's Business English Civic Education is at a good level, which is highly related to the high quality of his teaching in the dimension of political quality.

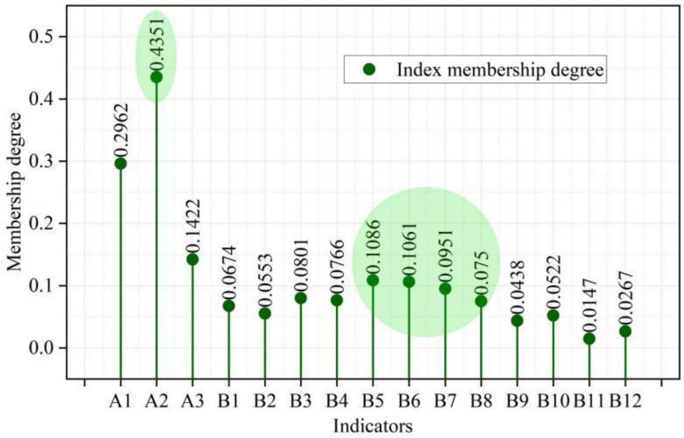

Figure 2. Comprehensive cloud evaluation result of scores of each indicator

4. Conclusion

This paper proposes to establish a fuzzy evaluation model to quantify the effect of Business English Civic and Political Education. The CR values of the results of indicator weight assignment are all >0.0070 and <0.1000, and the comparison of the weights of each indicator can reflect the importance of the dimensions of Business English Civic and Political Education. Through the fuzzy evaluation model, the achievement of specific index quantities can be effectively analyzed from the evaluation affiliation and score, and the multi-level evaluation and comprehensive evaluation of the classroom teaching effect of the corresponding teachers of Business English Civic and Political Education is realized (comprehensive affiliation > 0.05).

Funding

This research was supported by the Research on Cultivation of "Four Dimension-integration" Inter-disciplinary Talents in Business English Major under the Background of New Liberal Arts (202401001459).

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