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A Multi-Criteria Decision-Making Approach with Hyper Soft Set to Teaching Quality Assessment in English Language and Literature

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Abstract: The training ground for professional English speakers is the English departments of colleges and universities. Economic development and international interactions are impacted by the quality of their instruction. This study created an evaluation method with for evaluating the quality of English language and literature using questionnaire surveys, interviews, and a review of the literature. The multi-criteria decision making (MCDM) method is used in this study to evaluate the English langue and literature. Neutrosophic set is integrated with the MCDM method to deal with uncertainty and value information. This study uses the CRITIC method to compute the criteria weights. The CRITIC method is used under the neutrosophic sets and hyper soft set (HSS) to deal with various criteria. This study uses six main criteria and 23 sub criteria to be evaluated and select the highest importance criterion in decision making problem. Three experts are evaluated the criteria. The results show the Pedagogical Competence of Educators of English Language has the highest rate.

Keywords: Hyper Soft Set; Single Valued Neutrosophic Sets; Teaching Quality Assessment in English Language and Literature; MCDM Method.

1. Introduction and Literature Review

The status of English instruction in higher education has increased as a result of China's implementation of the reform and opening-up policy in the context of global economic integration and Chinese citizens' increased emphasis on learning English as a lingua franca. To prepare China for future international competition, Chinese colleges and universities have established English departments one after another[1], [2].

These departments have produced several English major graduates over the years, but the caliber of these graduates is not up to par. Thus, evaluating the college English department's teaching quality has emerged as a crucial and pressing responsibility for English teachers to raise the caliber of English instruction and the overall caliber of English graduates[3], [4].

There have been three phases in the evolution of educational evaluation in western nations. The first stage, known as the "germination period," lasted from the middle of the nineteenth century to the 1930s[5], [6]. During this time, there was no standardized and objective assessment system in place, and students' abilities and the quality of instruction were assessed based on subjective impressions and personal experience. The second stage, known as the formation phase, spanned the 1930s through the 1950s. During this time, education assessment was more thorough, and additional evaluation techniques, such as the well-known "Tyler Evaluation Model," were established[7], [8].

The third stage, known as the "heyday stage," spans the 1950s to the present and is characterized by a high regard for education assessment, a wealth of research on the subject, and a far greater variety and breadth of modes, objects, methods, and forms of education assessment[9], [10]. Evaluation of English language is a MCDM methodology.

The discovery of single-valued neutrosophic sets (SVNSs) theory inspired us to investigate the potential use in English language evaluation because of imprecise knowledge, the hazy human mind, and inconsistent information. This is the first research to provide a framework for evaluating multi-criteria English language evaluation using the CRITIC technique in the context of SVNS. The CRITIC approach's goal attribute weights are more logical for the MCDM models to achieve this[11], [12].

In several fields, the theory of fuzzy sets (FSs) has been widely used to address the resulting uncertainty. Many FS generalizations have been proposed and used to various decision-making challenges over the years. However, the concepts of FSs and their expansions are only able to handle imprecise and partial data; they are unable to address the inconsistent and ambiguous data that arises in actual MCDM concerns. Smarandache created the neutrosophic set (NS) doctrine in order to get around this problem. It is divided into three independent categories: truth-belongingness grade (TG), indeterminacy-belongingness grade (IG), and falsity-belongingness grade (FG)[13], [14].

It is difficult to apply the NSs in scientific and engineering fields because of their intricate interpretation. Wang et al. developed the idea of SVNSs, whose belongingness grades fall between [0,1], to get around the issue. One specific instance of NSs is the SVNSs[15], [16]. Assessing the criteria weights is a crucial task for DEs in the MCDM process. Many academics have proposed various methods for determining the weight of the criteria.

To determine how many criteria or factors contribute to a given goal, the objective weighting approach is applied. This strategy removes the need for subjective assessments by allocating weights based on thorough data analysis and statistical methodologies. For example, in the field of cluster analysis, the objective weighting approach is used to determine the significance of each attribute in the clustering process. Instead than relying on subjective human evaluations, this method is based on mathematical algorithms and the structural characteristics of the data. Consequently, it guarantees that the clustering results are more accurate and objective, successfully reducing any biases brought about by subjective considerations.

The objective weighing method is widely used in many different fields, using scientific data analysis techniques to assess the importance of each variable or indication and give decision-makers more accurate and trustworthy information. The entropy weight method, standard deviation method, and CRITIC approach are currently widely used objective weighting techniques. In different situations, each approach exhibits distinct performance advantages and disadvantages[17].

There are two types of criteria for weight determination processes: objective and subjective weights. The CRITIC tool was developed in 1995 by Diakoulaki et al. to determine the objective weight of criteria[18]. The standard deviation (SD), which is a measure of the criteria's contrast intensity, is used to assess the objective weight of the criteria to use the CRITIC process.

On the other hand, the correlation coefficient is used to compute conflicts between the criteria. In several real-world MCDM issues, the CRITIC tool has been effectively utilized to calculate the objective weights of criteria[19], [20].

Hypersoft (HSS) subset, HS complement, not HSS set, absolute set, union, intersection, AND, OR, restricted union, extended intersection, relevant complement, restricted difference, restricted symmetric difference, HSS set relation, sub relation, complement relation, HSS representation in matrix form, various operations on matrices, and the application of similarity measure technique for medical diagnosis purposes in a neutrophilic environment are just a few of the fundamental concepts that Saeed et al. explained[21]. After characterizing mapping in a hypersoft set setting, Saeed et al. went on to examine some of its key characteristics, such as HS images and HS inverse images[22].

The topic of hypersoft points in various fuzzy-like settings was covered by Mujahid et al.[23] Rahman et al. [24] introduced complex HSS in 2020 and created the hybrids of the HS set using a complex neutrosophic set and a complex fuzzy set, respectively, with a complex intuitionistic fuzzy set. Along with their theoretical operations (complement, union, intersection, etc.), they also covered their foundations, which include subsets, equal sets, null sets, absolute sets, etc. Convexity cum concavity on HSS was conceptualized in 2020, and its pictorial representations with illustrative instances were provided[25].

Illustrative Example

Let $A = (p_1, p_2, \dots, p_{10})$ be a set of mobile phones and a person wants to buy a mobile. But the mobile has different alternatives.

The attributes of the mobile are:

$a_1 = Back\ Camera$

$a_2 = RAM$

$a_3 = Storage$

$a_4 = Font\ Camera$

The attributes values are:

$A_1 = \{16MP, 32MP, 48MP\}$

$A_2 = \{3GB, 4GB, 8GB\}$

$A_3 = \{16GB, 32GB, 64GB\}$

$A_4 = \{2MP, 4MP, 8MP\}$

The HSS is:

$Let\ C = A_1 \times A_2 \times A_3 \times A_4$Then the HSS is a function that can be obtained such as:

$f\{48MP, 8GB, 32GB, 8MP\}$

The study's primary contributions are described as follows:

a) A unified HSS-SVN-CRITIC framework for addressing MCDM difficulties is offered.
b) The attribute weights are calculated using the CRITICAL structure.
c) To demonstrate the stability and permanence of the created technique, a real-world case study of English language evaluation is provided inside the SVNS environment.

The following is a summary of the remainder of the manuscript: Section 2 shows the steps of the HSS-SVNS-CRITIC method. Section 3 shows the case study results. Section 4 shows the conclusions.

2. Concepts of SVNSs

The neutrosophic set has three membership functions such as Truth, indeterminacy, and falsity[26], [27].

$y = \left(x, T_y(x), I_y(x), F_y(x), x \in X\right)$

$-0 \leq \sup T_y(x) + \sup I_y(x) + \sup F_y(x) \leq 3+$

Let two SVNNs such as: $x = (a_1, b_1, c_1)$ *and* $y = (a_2, b_2, c_2)$

$x \oplus y = (a_1 + a_2 - a_1 a_2, b_1 b_2, c_1 c\_2)$

$x \otimes y = (a_1 a_2, b_1 + b_2 - b_1 b_2, c_1 + c_2 - c_1 c_2)$

$\curlywedge x = (1 - (1 - a_1)^{\curlywedge}, b_1^{\curlywedge}, c_1^{\curlywedge})$

$x^{\curlywedge} = (a_1^{\curlywedge}, 1 - (1 - b_1)^{\curlywedge}, 1 - (1 - c_1)^{\curlywedge}), \curlywedge > 0$

We can obtain the score function as:

$f(x) = \frac{2 + T(x) - I(x) - F(x)}{3}$

2. Proposed Model: Soft MCDM Models with HSS

In this part, the steps of the proposed method for evaluation criteria and obtain the weights of criteria ae presented. The proposed method uses the CRITIC method to compute the criteria weights. The proposed method is implemented using the single valued neutrosophic sets (SVNSs)[28], [29]. Figure 1 shows the steps of this study.

The hyper soft set (HSS) definition can be defined as:

Let y be a universe of discourse, (y) the power set of y, and A set of criteria. Then the pair $(F, y), F: A \rightarrow (y)$ called a soft set over y

The HSS can be defined as[30], [31]:

Let y be a universe of discourse, (y) the power set of y, and $a_1, a_2, \ldots, a_n; n \geq 1$ set of criteria. Then the pair, $F: A_1 \times A_2 \times \ldots A_n \rightarrow (y)$ called a hyper soft set over y.

- Determine the main criteria, sub criteria to be evaluated in this study
- Construct a panel of experts to evaluate the criteria.
- Build the decision matrix between criteria and alternatives.
- Use SVNNs to evaluate the criteria and alternatives. Then use the score function to obtain crisp value.
- Combine the values of decision matrix.
- Then we apply the steps of the CRITIC method to obtain the criteria weights.
- Normalize the decision matrix for the beneficial and non-beneficial factors

$$T_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (1)$$

$$T_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

- Compute the standard deviation

$$d_j = \sqrt{\frac{\sum_{i=1}^{m}\left(T_{ij}-T_j^-\right)}{m}} \quad (3)$$

$$T_j^- = \frac{1}{m}\sum_{i=1}^{m} T_{ij} \quad (4)$$

- Determine the correlation matrix between the criteria

$$p_{jk} = \frac{\sum_{i=1}^{m}\left[T_{ij}-T_j^-\right]\left[T_{ik}-T_k^-\right]}{\sqrt{\sum_{i=1}^{m}\left[\left(T_{ij}-T_j^-\right)^2\right]\sum_{i=1}^{m}\left(T_{ik}-T_k^-\right)^2}} \quad (5)$$

- Compute the information measure

$$Q_i = d_j \sum_{i=1}^{m}\left(1-p_{jk}\right) \quad (6)$$

- Compute the criteria weights.

$$w_j = \frac{Q_i}{\sum_{j=1}^{n} Q_i} \quad (7)$$

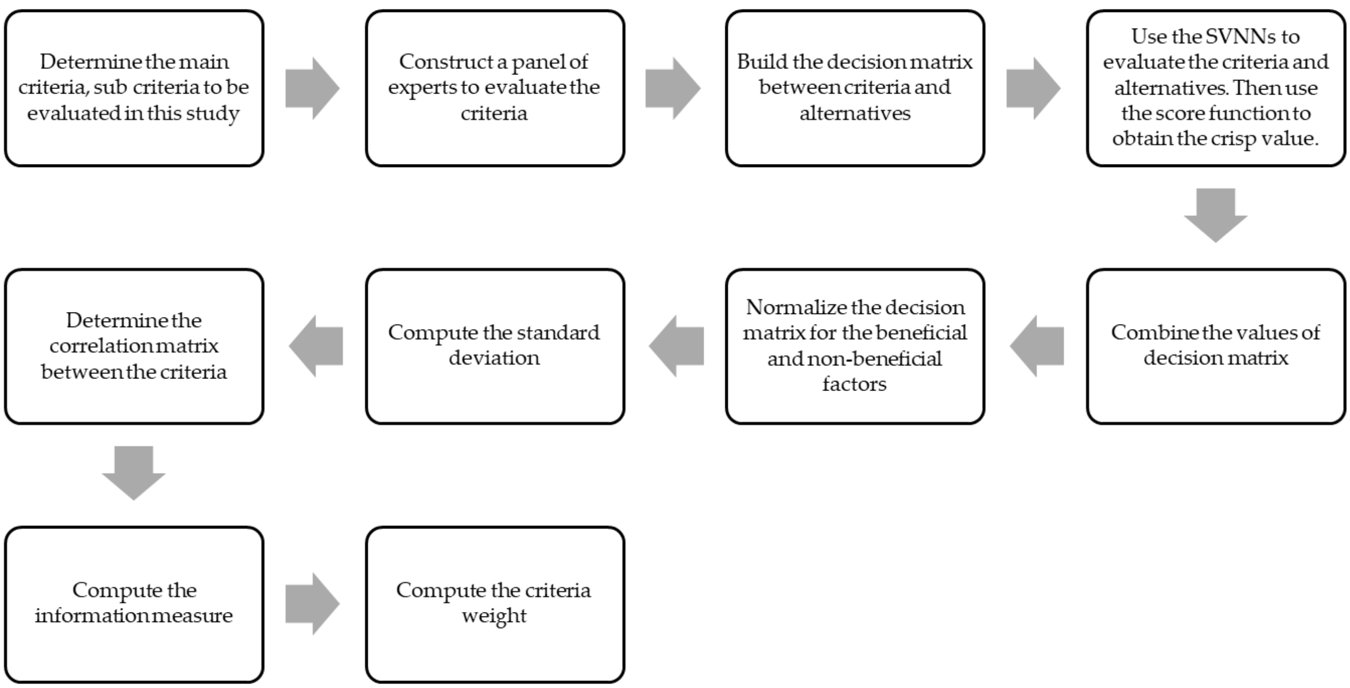

Figure 1. The steps of SVN-HSS-CRITIC Method.

3. Case Study

This section presents the outcomes of the CRITIC methodology to compute the criteria weights.

3.1 Comprehensive overview

This section shows the methodology used in this study. Three experts are evaluated the main and sub criteria. Six main criteria and 23 sub criteria are used in this study. Table 1 shows the main and sub criteria of this study.

Table 1. The criteria and values.

	Main criteria	Sub criteria
C_1	Assessment Effectiveness of English Language	Highly Effective Effective Somewhat Effective Ineffective
C_2	Student Engagement of English Language	High Medium Low
C_3	Curriculum Relevance of English Language	Very Relevant Relevant Slightly Relevant Irrelevant
C_4	Technological Integration of English Language	Excellent Good Fair Poor
C_5	Cultural and Inclusivity Factors of English Language	Highly Inclusive Inclusive Slightly Inclusive Non-Inclusive
C_6	Pedagogical Competence of Educators of English Language	Strong Moderate Weak Very Weak

The criteria of this study are: Pedagogical Competence of Educators

Description: Measures the teacher's ability to design, deliver, and assess learning effectively in English language and literature.

Values:

- Strong
- Moderate
- Weak
- Very Weak

Student Engagement

Description: Assesses the extent to which students actively participate in classes, discussions, and assignments.

Values:

- High

- Medium
- Low

Curriculum Relevance

Evaluates how well the syllabus aligns with modern linguistic and literary trends, as well as job market requirements.

Values:

- Very Relevant
- Relevant
- Slightly Relevant
- Irrelevant

Assessment Effectiveness

Examines the appropriateness and fairness of evaluation methods used, including written exams, oral presentations, and projects.

Values:

- Highly Effective
- Effective
- Somewhat Effective
- Ineffective

Technological Integration

Assesses the use of digital tools, such as online resources, multimedia, and learning management systems, in teaching.

Values:

- Excellent
- Good
- Fair
- Poor

Cultural and Inclusivity Factors

Measures how well the teaching approach accommodates diverse cultural backgrounds and learning needs.

Values

- Highly Inclusive
- Inclusive
- Slightly Inclusive
- Non-Inclusive

let $C = C_1 \times C_2 \times C_3 \times C_4 \times C_5 \times C_6$ and the criteria values are $(A_1, A_2, \dots, A_{23})$. We select the six attributes as $A = A_1 \times A_5 \times A_8 \times A_{12} \times A_{16} \times A_{20}$.

Three experts have evaluated the criteria as shown in Table 2. Then we obtain the crisp values and combine the decision matrix.

Table 2. The decision matrix.

	A_1	A_5	A_8	A_{12}	A_{16}	A_{20}
Alt_1	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.6,0.7)
Alt_2	(0.1,0.9,0.9)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.4,0.6,0.7)	(0.3,0.7,0.8)
Alt_3	(0.2,0.8,0.9)	(0.7,0.3,0.4)	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.3,0.7,0.8)	(0.2,0.8,0.9)
Alt_4	(0.3,0.7,0.8)	(0.1,0.9,0.9)	(0.8,0.2,0.3)	(0.5,0.5,0.5)	(0.2,0.8,0.9)	(0.1,0.9,0.9)
Alt_5	(0.4,0.6,0.7)	(0.2,0.8,0.9)	(0.3,0.7,0.8)	(0.4,0.6,0.7)	(0.1,0.9,0.9)	(0.9,0.1,0.2)
Alt_6	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)
	A_1	A_5	A_8	A_{12}	A_{16}	A_{20}
Alt_1	(0.5,0.5,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.6,0.7)
Alt_2	(0.4,0.6,0.7)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.5,0.5,0.5)	(0.4,0.6,0.7)	(0.3,0.7,0.8)
Alt_3	(0.3,0.7,0.8)	(0.5,0.5,0.5)	(0.5,0.5,0.5)	(0.4,0.6,0.7)	(0.3,0.7,0.8)	(0.2,0.8,0.9)
Alt_4	(0.3,0.7,0.8)	(0.4,0.6,0.7)	(0.4,0.6,0.7)	(0.3,0.7,0.8)	(0.2,0.8,0.9)	(0.1,0.9,0.9)
Alt_5	(0.4,0.6,0.7)	(0.3,0.7,0.8)	(0.3,0.7,0.8)	(0.4,0.6,0.7)	(0.1,0.9,0.9)	(0.9,0.1,0.2)
Alt_6	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)
	A_1	A_5	A_8	A_{12}	A_{16}	A_{20}
Alt_1	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.7,0.3,0.4)	(0.5,0.5,0.5)	(0.4,0.6,0.7)
Alt_2	(0.1,0.9,0.9)	(0.9,0.1,0.2)	(0.1,0.9,0.9)	(0.1,0.9,0.9)	(0.4,0.6,0.7)	(0.7,0.3,0.4)
Alt_3	(0.2,0.8,0.9)	(0.7,0.3,0.4)	(0.2,0.8,0.9)	(0.2,0.8,0.9)	(0.7,0.3,0.4)	(0.1,0.9,0.9)
Alt_4	(0.3,0.7,0.8)	(0.1,0.9,0.9)	(0.8,0.2,0.3)	(0.5,0.5,0.5)	(0.1,0.9,0.9)	(0.2,0.8,0.9)
Alt_5	(0.4,0.6,0.7)	(0.2,0.8,0.9)	(0.3,0.7,0.8)	(0.4,0.6,0.7)	(0.2,0.8,0.9)	(0.9,0.1,0.2)
Alt_6	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)

- Eq. (1) is used to normalize the decision matrix as shown in table 3.

- Eq. (4) is used to compute the mean value. Then Eq. (3) is used to obtain the standard deviation value.

- Then we determine the correlation matrix between the criteria using Eq. (5) as shown in Table 4 and Figure 2.

- Then we determine the information measure.

- Eq. (7) is used to compute the criteria weights as shown in Table 5 and Figure 3. Figure 4 shows the rank of criteria.

Table 3. Normalized decision matrix.

	A_1	A_5	A_8	A_{12}	A_{16}	A_{20}
Alt_1	1	0.852459	1	0.583333	0.507463	0.328358
Alt_2	0	1	0.694444	0.138889	0.328358	0.373134
Alt_3	0.022727	0.622951	0.611111	1.39E-16	0.373134	0.029851
Alt_4	0.159091	0	0.916667	0.138889	0.029851	0
Alt_5	0.363636	0.016393	0	0	0	1
Alt_6	0.636364	0.557377	1	1	1	0.865672

Table 4. Correlation matrix.

	A_1	A_5	A_8	A_{12}	A_{16}	A_{20}
A_1	1	0.144286	0.349098	0.719378	0.47755	0.364949
A_5	0.144286	1	0.425733	0.295609	0.539045	-0.17064
A_8	0.349098	0.425733	1	0.652608	0.5961	-0.44765
A_{12}	0.719378	0.295609	0.652608	1	0.888719	0.36274
A_{16}	0.47755	0.539045	0.5961	0.888719	1	0.257437
A_{20}	0.364949	-0.17064	-0.44765	0.36274	0.257437	1

Table 5. The criteria weights.

	Weights	Rank
A_1	0.151511	3
A_5	0.206735	5
A_8	0.170967	4
A_{12}	0.109267	2
A_{16}	0.107595	1
A_{20}	0.253924	6

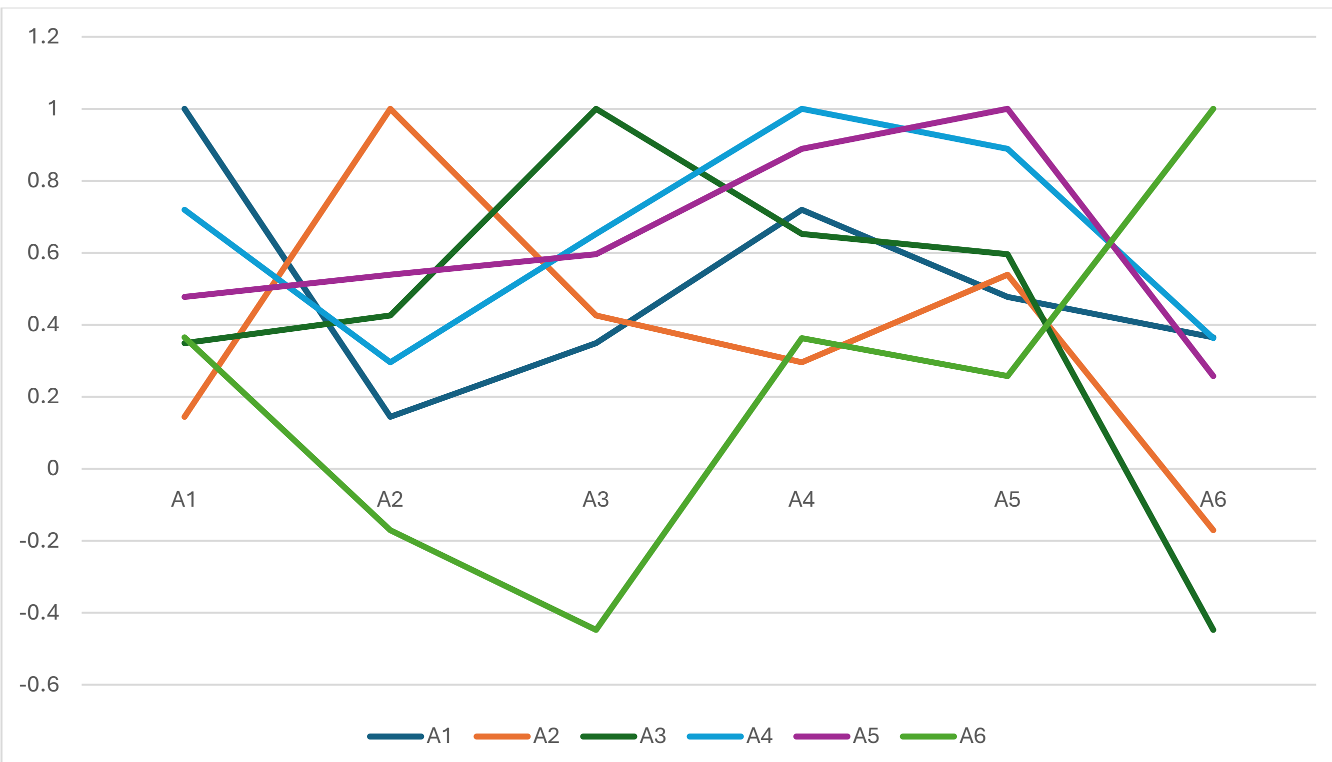

Figure 2. The correlation between criteria.

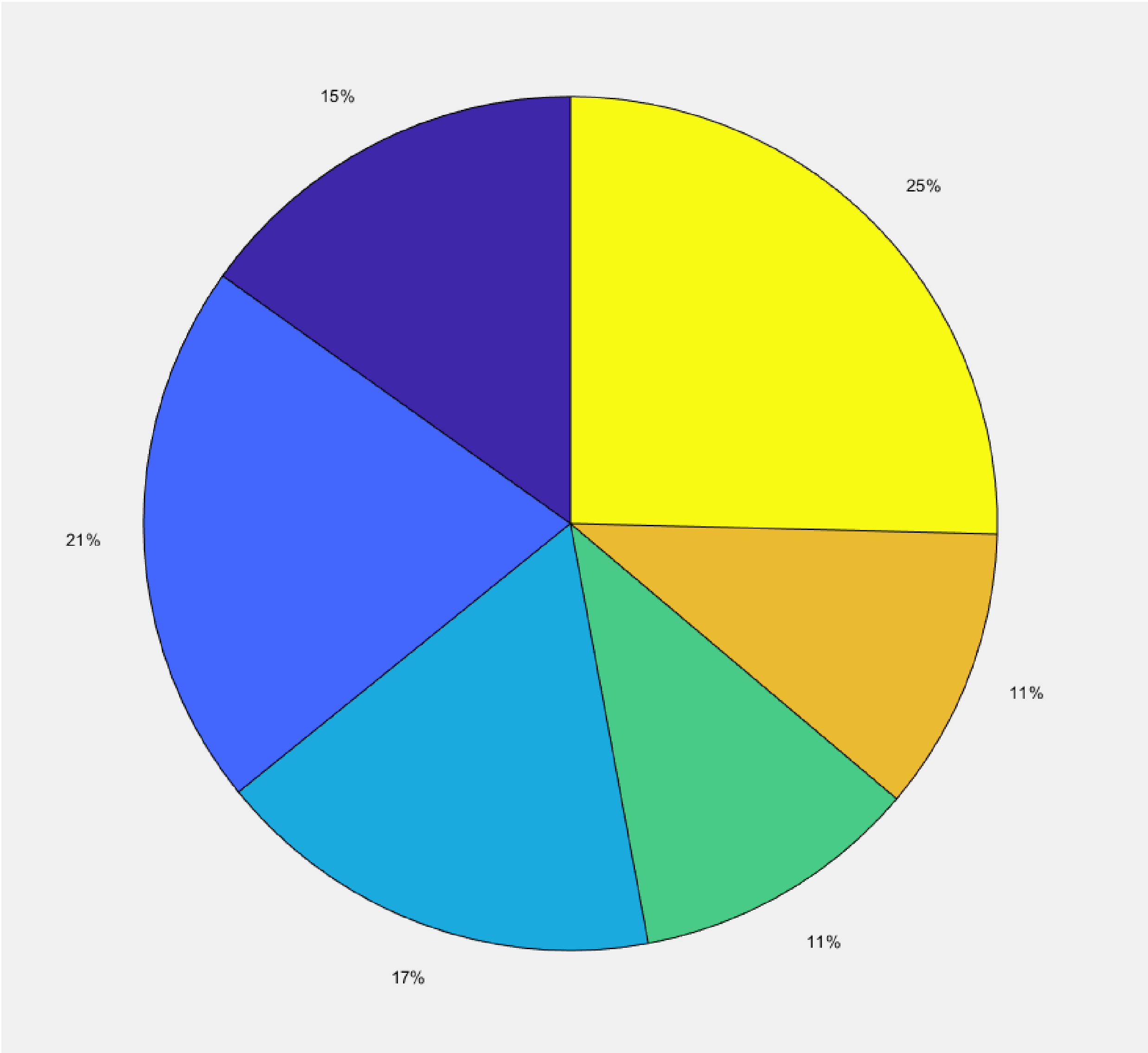

Figure 3. The criteria weights.

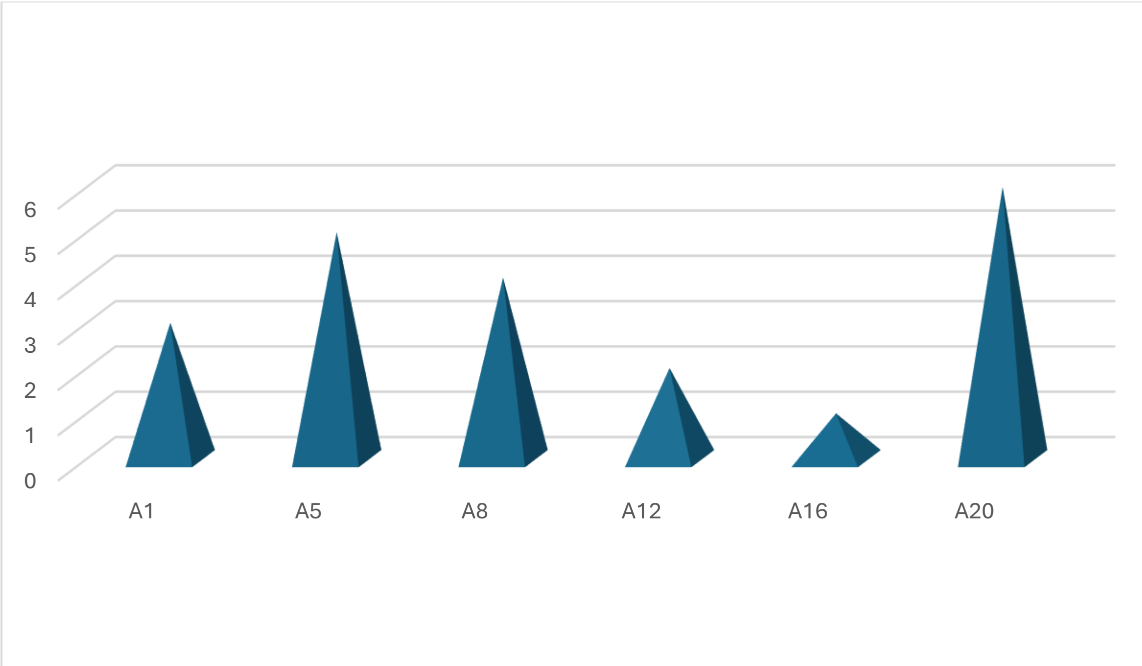

Figure 4. The rank of criteria.

4.1 Comparison Analysis

This section shows the comparative analysis between our models and other MCDM methods such as Entropy, BWM, AHP and SWARA methods. We show a high correlation between our model and other MCDM methods. The comparative analysis shows the effectiveness of the proposed approach. Figure 5 shows the comparative analysis results.

By multiplying the contrast strength inside the criteria by the conflict between them, the CRITIC technique methodically assesses the objective weight between criteria. Normalizing an indicator is crucial before using the CRITIC approach for weight calculation to lessen the impact of its dimensions and value range variations.

When correlations are positive, the Pearson correlation coefficient, which only evaluates linear correlations—is unable to adequately capture the whole independence between criteria. In these situations, the independence of criterion would be better described by substituting a metric that can identify non-linear correlations for the Pearson correlation coefficient. Data redundancy may result from the CRITIC method's assignment of higher weights to criteria with stronger negative correlations. The relative value of other criteria would be diminished if, for instance, two criteria with perfect negative correlation were given disproportionately large weights, so double counting their contributions. An unfair weighted distribution may result from this.

Regardless of whether the correlation is positive or negative, integrating the correlation coefficient's absolute value could help address the issue of significant data redundancy. To more successfully address these problems, it is still advisable to consider an alternate index that can capture nonlinear interactions, while the Pearson correlation coefficient is only able to capture linear relationships.

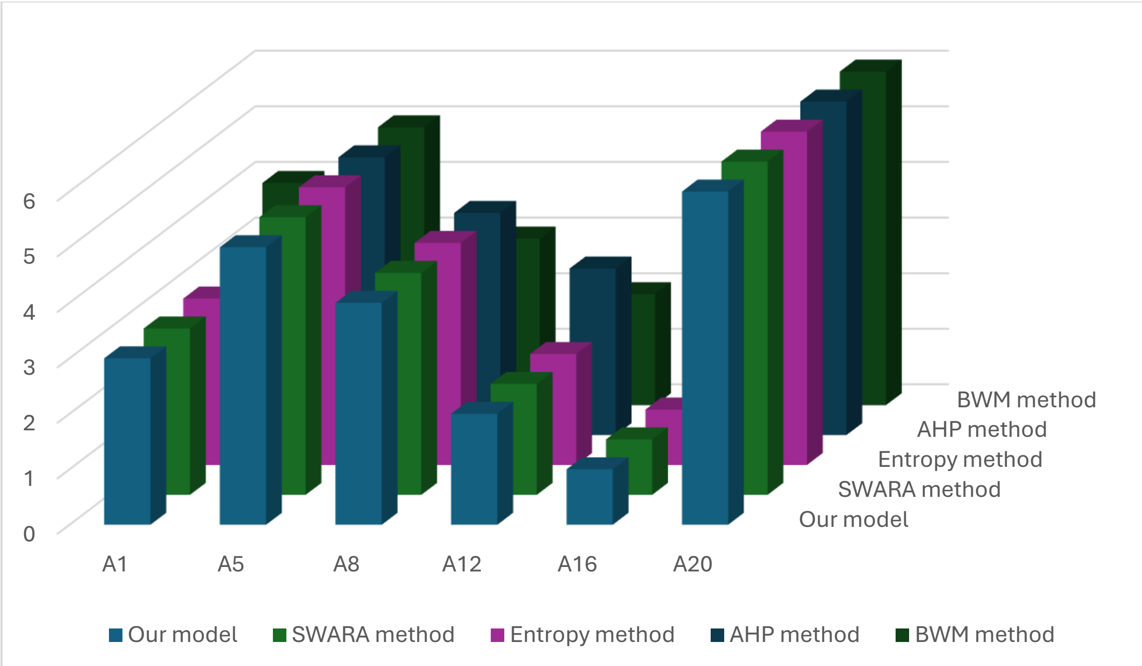

Figure 5. The comparative analysis results.

Despite being widely applied in many different sectors, the CRITIC approach has many drawbacks. Only linear correlation can be measured by the Pearson correlation employed in the CRITIC technique. In several fields, such as computer vision, computational biology, and medical imaging, it becomes necessary to evaluate the actual dependence or independence of complicated objects. Many statistical techniques are available for testing dependence in addition to linear correlation. For example, distance covariance, which calculates the separation between the joint characteristic function of two random vectors and the product of their individual marginal characteristic functions.

The distance coefficient is divided by the product of the corresponding distance variances under the root sign to determine the distance correlation coefficient, which is defined similarly to the Pearson correlation coefficient. In contrast to the Pearson correlation, which only shows the lack of a linear relationship, a distance correlation coefficient of 0 denotes total independence between two random vectors. The Pearson correlation coefficient lacks the ability to capture non-linear correlations, whereas the distance correlation coefficient does.

4. Conclusions and Future Work

Higher education institutions' English departments must provide high-quality instruction to develop English professionals and transfer skilled individuals to the community. This study used the factor analysis approach to examine and investigate the evaluation of the college English department's teaching quality. This study uses the CRITIC method to compute the criteria weights. The CRITIC method is an MCDM method used to deal with various criteria. The CRITIC method is combined with the single valued neutrosophic sets to deal with vague and uncertainty information. We used the hyper soft set approach in this study to select from various values of each criterion. This study invited three experts to evaluate the 6 main criteria and 23 values of each criterion. The results show the Pedagogical Competence of Educators of English Language has the highest importance.

In the future work, the proposed approach can apply different decision-making problems to compute the criteria weights. There are different MCDM approaches that can be applied in this study to compute criteria weights such as Entropy method, SWARA method and others.

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