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Integrating KEMIRA with Interval-Valued Neutrosophic Numbers to Assess University English Teaching Quality: A Multi-Attribute Decision-Making Model

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Abstract

Evaluating the quality of university English teaching is essential for improving learning outcomes. Key factors include teaching methods, curriculum design, and teacher-student interaction. Effective teachers use engaging approaches that help students develop skills in reading, writing, listening, and speaking. Tailored course content and regular feedback mechanisms, such as surveys and assessments, enhance learning efficiency and address challenges. Teachers' enthusiasm and ability to motivate students greatly influence the quality of teaching. Emphasizing practical communication skills prepares students for real-world applications. This paper introduces the KEmeny Median Indicator Ranks Accordance (KEMIRA) method, combined with interval-valued neutrosophic sets (INSs), to address multiple-attribute decision-making (MADM) problems. A numerical example evaluates the quality of university English teaching, showcasing the advantages of the interval-valued neutrosophic KEMIRA (INN-KEMIRA) approach. Key contributions include extending the KEMIRA model to INSs, determining attribute weights using the average method, and applying INN-KEMIRA to complex MADM problems. A practical case study demonstrates the effectiveness of this approach, with comparative analyses and sensitivity tests validating its accuracy and reliability. This framework provides a robust solution for decision-making under uncertainty, offering valuable insights for educational quality evaluation and similar challenges.

Keywords: Multiple-attribute decision-making (MADM); interval-valued neutrosophic sets (INSs); KEMIRA approach; university English teaching quality evaluation

1. Introduction

The quality of college English teaching reflects the effectiveness of instructional strategies, curriculum design, and student learning outcomes. High-quality teaching ensures that students not only improve their language proficiency but also develop critical thinking, communication, and cross-cultural skills. It involves a well-structured curriculum, engaging teaching methods, and the integration of innovative approaches, such as blended learning and student-centered instruction. The quality is also influenced by the teacher's professional competence, teaching attitude, and ability to adapt to diverse student needs. With the rise of online education, the use of digital tools and platforms has become a key factor in enhancing teaching quality. Moreover, the alignment of teaching goals with application-oriented and globalized demands has led to reforms that emphasize practical skills and real-world application. Ultimately, quality teaching aims to create an interactive, inclusive, and effective learning environment that equips students with the skills needed for academic and professional success. The quality of college English teaching reflects the effectiveness of instructional strategies, curriculum design, and student learning outcomes. High-quality teaching ensures that students not only improve their language proficiency but also develop critical thinking, communication, and cross-cultural skills. It involves a well-structured curriculum, engaging teaching methods, and the integration of innovative approaches, such as blended learning and student-centered instruction. The quality is also influenced by the teacher's professional competence, teaching attitude, and ability to adapt to diverse student needs. With the rise of online education, the use of digital tools and platforms has become a key factor in enhancing teaching quality. Moreover, the alignment of teaching goals with application-oriented and globalized demands has led to reforms that emphasize practical skills and real-world application. Ultimately, quality teaching aims to create an interactive, inclusive, and effective learning environment that equips students with the skills needed for academic and professional success. In recent years, research on the quality evaluation of college English teaching has deepened, with studies exploring the construction of evaluation systems, methodological improvements, and practical applications. The following is a chronological summary of these studies. Wang and Zhang [1] were among the first to propose the application of fuzzy comprehensive evaluation methods to assess college English classroom teaching quality and emphasized the scientific nature and feasibility of transforming qualitative indicators into quantitative ones. Li [2] analyzed the strengths and weaknesses of the classroom teaching quality monitoring mechanism at Jishou University, suggesting that only a scientific and standardized evaluation system could effectively improve teaching quality. Gao [3] explored the feasibility of integrating ISO9000 standards into college English teaching quality evaluation, offering a new perspective for building comprehensive evaluation systems. In 2017, Tu [4] introduced an interval fuzzy comprehensive evaluation method for college English teaching, arguing that this approach was more accurate and comprehensive than general fuzzy evaluation methods and effectively reduced information loss. Geng [5] constructed an all-process, full-procedure evaluation system for college English teaching under the framework of Outcome-Based Education (OBE). He highlighted the importance of student-centered and outcome-oriented evaluation methods. Li [6] focused on the application-oriented talent training model, proposing strategies for constructing a quality assurance evaluation system through teaching reforms to meet students' professional development needs. In the same year, Yan et al. [7] developed a college English teaching quality evaluation index system based on the SPOC model, aiming to cultivate students' autonomous learning and innovation abilities and argued that online teaching provided significant opportunities for improving teaching quality. Cui [8] established a quality evaluation system for college English teaching based on the concept of curriculum ideology, including aspects such as teaching plans, teaching processes, and teaching outcomes, providing valuable references for curriculum reform. Zhang [9] introduced a value-driven evaluation model, comparing students' "expectations" with their "actual experiences" to analyze the role of value-based thinking in college English teaching and proposed measures for improvement. Finally, He [10] examined the impact of formative assessment on the quality of blended online and offline teaching and argued that the widespread use of internet technologies has significantly facilitated teaching quality evaluation. In conclusion, these studies, approaching the subject from various dimensions and methodologies, have gradually constructed and refined the evaluation system for college English teaching quality, providing theoretical support and practical guidance for improving teaching quality.

The problem of evaluating university English teaching quality is MADM task. Recently, the KEMIRA approach [11,12,13] has been applied to address various MADM problems effectively. Meanwhile, INSs [14] have emerged as a powerful tool for representing and handling uncertain, imprecise, or incomplete information, which is often encountered in real-world evaluations such as teaching quality assessment. However, to date, no research has extended the modified KEMIRA approach to the framework of INSs [14].

1.1 Motivation of This Study

I. The primary motivation and research aim of this paper are to bridge this gap by extending the modified KEMIRA approach to INSs and developing a corresponding MADM model for university English teaching quality evaluation.

II. Specifically, this paper proposes the INN- KEMIRA approach, which integrates the KEMIRA concept with INSs to handle MADM problems under uncertainty.

III. By combining the KEMIRA approach with INSs, the INN- KEMIRA approach is designed to provide a robust and systematic methodology for evaluating teaching quality.

IV. To demonstrate the effectiveness and practicality of the established approach, a numerical example is provided that focuses on university English teaching quality evaluation. Moreover, comparative analyses are conducted to highlight the advantages and rationality of the INN- KEMIRA approach.

V. The results show that the established method is capable of handling uncertain information more effectively than traditional methods, making it a valuable tool for decision-making in uncertain environments.

1.2 Main Contributions of This Study

This study provides a novel framework for addressing MADM problems and offers a practical solution for evaluating teaching quality in uncertain and complex environments. The main contributions and research objectives of this paper are summarized:

(1) The KEMIRA model is extended to the INSs framework.

(2) The average approach is adopted to construct attribute weights under INSs, ensuring a more objective evaluation process.

(3) The INN- KEMIRA approach is developed to address MADM problems in the context of INSs, providing a novel solution for uncertain decision-making.

(4) A practical case study on university English teaching quality evaluation is presented to illustrate the validity and applicability of the established method.

(5) Comparative algorithms are implemented to verify the rationality, effectiveness, and advantages of the INN- KEMIRA approach.

The structure of this paper is organized as follows. Section 2 introduces the fundamental concepts of INSs, providing the theoretical basis for the study. In Section 3, the KEMIRA approach is developed to address MADM problems within the framework of INSs. Section 4 presents a case study focused on evaluating university English teaching quality, demonstrating the practical application of the established method. Additionally, a comparative analysis is conducted to validate the effectiveness and advantages of the approach. Finally, the study concludes in Section 5, summarizing the findings and highlighting potential directions for future research.

2. Preliminaries

This section introduces the fundamental operations of interval-valued neutrosophic sets (INSs) and provides an overview of the KEMIRA approach. These concepts form the basis for the proposed methodology, integrating INSs with KEMIRA to address MADM problems.

2.1 Definition [15]. The SVNSs is established:

$$KA=\left\{\left(\vartheta, KT_A(\vartheta), KI_A(\vartheta), KF_A(\vartheta)\right) \middle| \vartheta\in\Phi\right\} \tag{1}$$

where the $KT_A(\vartheta), KI_A(\vartheta), KF_A(\vartheta)$ portrays the truth-membership (TM), indeterminacy-membership (IM) and falsity-membership (FM), $KT_A(\vartheta), KI_A(\vartheta), KF_A(\vartheta)\in[0,1]$ and satisfies $0\le KT_A(\vartheta)+KI_A(\vartheta)+KF_A(\vartheta)\le 3$.

Wang et al. [14] established the INSs.

2.2 Definition [14]. The INSs is established:

$$SA=\left\{\left(\vartheta, ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta)\right) \middle| \vartheta\in\Phi\right\} \tag{2}$$

where the $ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta)$ portray the TM, IM and FM, $ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta)\subseteq[0,1]$ and satisfies $0\le \sup ST_A(\vartheta)+\sup SI_A(\vartheta)+\sup SF_A(\vartheta)\le 3$.

The interval neutrosophic number (INN) is established: $SA=\left(ST_A, SI_A, SF_A\right)=\left(\left[STL_A, STU_A\right],\left[SIL_A, SIU_A\right],\left[SFL_A, SFU_A\right]\right)$, where $ST_A, SI_A, SF_A\subseteq[0,1]$, and $0\le STU_A+SIU_A+SFU_A\le 3$.

2.3 Definition [16]. Let $SA=\left(\left[STL_A, STU_A\right],\left[SIL_A, SIU_A\right],\left[SFL_A, SFU_A\right]\right)$ be INN, the score value is established:

$$SV(SA)=\frac{(2+STL_A-SIL_A-SFL_A)+(2+STU_A-SIU_A-SFU_A)}{6},$$

$$SV(SA)\in[0,1]. \quad (2)$$

2.4 Definition [16]. Let $SA=([STL_A,STU_A],[SIL_A,SIU_A],[SFL_A,SFU_A])$ be INN, an accurate value is established:

$$AV(SA)=\frac{(STL_A+STU_A)-(SFL_A+SFU_A)}{2},\ AV(SA)\in[-1,1]. \quad (3)$$

The larger $AV(SA)$ is, the more $SA=([STL_A,STU_A],[SIL_A,SIU_A],[SFL_A,SFU_A])$ is.

Huang, Wei and Wei [16] established the order for INNs.

2.5 Definition [16]. Let $SA=([STL_A,STU_A],[SIL_A,SIU_A],[SFL_A,SFU_A])$ and $SB=([STL_B,STU_B],[SIL_B,SIU_B],[SFL_B,SFU_B])$, let $SV(SA)=\frac{(2+STL_A-SIL_A-SFL_A)+(2+STU_A-SIU_A-SFU_A)}{6}$ and $SV(SB)=\frac{(2+STL_B-SIL_B-SFL_B)+(2+STU_B-SIU_B-SFU_B)}{6}$, and let $AV(SA)=\frac{(STL_A+STU_A)-(SFL_A+SFU_A)}{2}$ and $AV(SB)=\frac{(STL_B+STU_B)-(SFL_B+SFU_B)}{2}$, respectively, then if $SV(SA)<SV(SB)$, $SA<SB$; if $SV(SA)=SV(SB)$, (1)if $AV(SA)=AV(SB)$, then $SA=SB$; (2) if $AV(SA)<AV(SB)$, $SA<SB$.

2.6 Definition [17]. Let $SA=([STL_A,STU_A],[SIL_A,SIU_A],[SFL_A,SFU_A])$ and $SB=([STL_B,STU_B],[SIL_B,SIU_B],[SFL_B,SFU_B])$, the operations are established:

$$(1)\ SA\oplus SB=\begin{pmatrix}\left(STL_A+STL_B-STL_ASTL_B,STU_A+STU_B-STU_ASTU_B\right),\\ \left[SIL_ASIL_B,SIU_ASIU_B\right],\left[SFL_ASFL_B,SFU_ASFU_B\right]\end{pmatrix};$$

$$(2)\ SA\otimes SB=\begin{pmatrix}\left[STL_ASTL_B,STU_ASTU_B\right],\\ \left[SIL_A+SIL_B-SIL_ASIL_B,SIU_A+SIU_B-SIU_ASIU_B\right],\\ \left[SFL_A+SFL_B-SFL_ASFL_B,SFU_A+SFU_B-SFU_ASFU_B\right]\end{pmatrix};$$

$$(3)\ \delta SA=\begin{pmatrix}\left[1-\left(1-STL_A\right)^{\delta},1-\left(1-STU_A\right)^{\delta}\right],\\ \left[\left(SIL_A\right)^{\delta},\left(SIU_A\right)^{\delta}\right],\left[\left(SFL_A\right)^{\delta},\left(SFU_A\right)^{\delta}\right]\end{pmatrix},\delta>0;$$

$$(4)\ \left(SA\right)^{\delta}=\begin{pmatrix}\left[\left(STL_A\right)^{\delta},\left(STU_A\right)^{\delta}\right],\left[\left(SIL_A\right)^{\delta},\left(SIU_A\right)^{\delta}\right],\\ \left[1-\left(1-SFL_A\right)^{\delta},1-\left(1-SFU_A\right)^{\delta}\right]\end{pmatrix},\delta>0.$$

2.7 Definition [18]. Let $SA=\left(\left[STL_A,STU_A\right],\left[SIL_A,SIU_A\right],\left[SFL_A,SFU_A\right]\right)$ and $SB=\left(\left[STL_B,STU_B\right],\left[SIL_B,SIU_B\right],\left[SFL_B,SFU_B\right]\right)$, the INN Euclidean distance (INNED) between $SA=\left(\left[STL_A,STU_A\right],\left[SIL_A,SIU_A\right],\left[SFL_A,SFU_A\right]\right)$ and $SB=\left(\left[STL_B,STU_B\right],\left[SIL_B,SIU_B\right],\left[SFL_B,SFU_B\right]\right)$ is established:

$$INNED\left(SA,SB\right)=\sqrt{\frac{1}{6}\begin{pmatrix}\left|STL_A-SL_B\right|^2+\left|STU_A-STU_B\right|^2+\left|SIL_A-SIL_B\right|^2+\\ \left|SIU_A-SIU_B\right|^2+\left|SFL_A-SFL_B\right|^2+\left|SFU_A-SFU_B\right|^2\end{pmatrix}} \quad (4)$$

2.1 The KEMIRA Method: Definition and Importance

The KEmeny Median Indicator Ranks Accordance (KEMIRA) method is a compensatory decision-making approach introduced by Krylovas et al. in 2014. This method is designed to rank various alternatives based on a set of criteria that are divided into two distinct groups within a decision matrix. The criteria are classified and prioritized by professionals, with their respective weights determined to ensure an accurate evaluation. KEMIRA's structured framework and adaptability make it an effective tool for solving complex decision-making problems.

One of KEMIRA's key features is its ability to handle criteria of different types, characteristics, and specialties by grouping them. For example, in real-world applications, criteria can be categorized into two or more groups to better reflect the priorities of decision-makers. This grouping allows for a more tailored and nuanced assessment, making the method particularly effective in addressing

MADM problems.

KEMIRA has gained significant attention in various fields due to its versatility and robustness. Researchers have applied and improved the method in numerous decision-making scenarios, including construction management, resource allocation, and educational quality evaluation. Its ability to incorporate professional expertise and classify criteria based on type and importance makes it a preferred choice in both academic and practical contexts.

In summary, the KEMIRA method provides a structured, flexible, and reliable approach to decision-making. By dividing criteria into meaningful groups and prioritizing them based on professional judgment, KEMIRA ensures a comprehensive and accurate evaluation process, making it indispensable for addressing complex decision-making challenges in various domains.

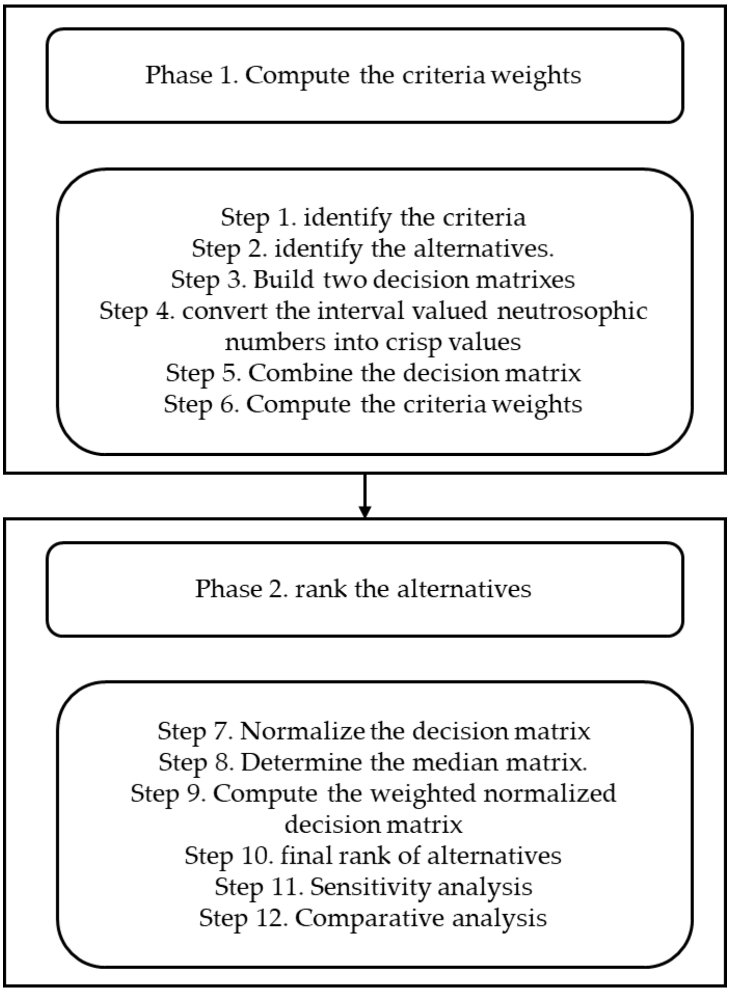

Figure 1. The steps of the proposed method.

3. Optimized KEMIRA Technique for Multi-Attribute Decision-Making Analysis

This section outlines the steps of the proposed method, as illustrated in Figure 1.

A. Building Two Decision Matrices

The decision matrices are constructed using two distinct groups of criteria, which are designed to evaluate the alternatives. The information is gathered from experts and decision-makers to ensure a comprehensive assessment of the criteria.

B. Normalizing the Decision Matrices

The normalization process is applied to both decision matrices. This includes adjustments for both positive and negative criteria to ensure consistency and comparability across all evaluation dimensions.

$$A_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (5)$$

$$B_{ij} = \frac{y_{ij} - \min y_{ij}}{\max y_{ij} - \min y_{ij}} \quad (6)$$

C. Determine the median matrix

The medium matrix is computed by the optimal value obtained from the different between the different matrices.

$$R_A = argmin \sum_{j=1}^{n} p\left(R_j, R_{j'}\right) \quad (7)$$

Where $p\left(R_j, R_{j'}\right)$ can be computed as:

$$p\left(R_j, R_{j'}\right) = \sum_{i=1}^{n} \sum_{j=1}^{n} \left|a_{ij}^{j} - a_{ij}^{j'}\right| \quad (8)$$

Where

$$a_{ij} = \begin{Bmatrix} 0 & if\ A_j < A_{j'} \\ 1 & if\ A_j > A_{j'} \end{Bmatrix} \quad (9)$$

D. Compute the criteria weights.

E. Compute the weighted normalized decision matrix

$$E_i = \sum_{j=1}^{n} A_{ij} w_{x_j} \quad (10)$$

$$F_i = \sum_{j=1}^{n} B_{ij} w_{y_j} \quad (11)$$

$$T(E, F) = \min \sum |E_i - F_i| \quad (12)$$

F. The final rank of alternatives

$$E_i + F_i = \sum_{j=1}^{n} A_{ij} w_{x_j} + \sum_{j=1}^{n} B_{ij} w_{y_j} \quad (13)$$

4. Implementation

This section presents the results of the proposed method. The evaluation of university English teaching quality is approached as a MADM problem. Ten local comprehensive and applied universities are assessed based on seven key attributes:

- Ability of instructors to deliver content
- Academic standards
- Tangible results
- Educational background
- Availability and quality of learning materials
- Student feedback
- Student performance

Table 1. Expert Opinions on Evaluation Criteria

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_2	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.8,0.9],[0.1,0.2],[0.1,0.2])
A_3	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])
A_4	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_5	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_6	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_7	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])
A_8	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])
A_9	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_{10}	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_2	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.8,0.9],[0.1,0.2],[0.1,0.2])
A_3	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])
A_4	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_5	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_6	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.8,0.9],[0.1,0.2],[0.1,0.2])
A_7	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.1,0.3],[0.1,0.2],[0.8,0.9])
A_8	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_9	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
A_{10}	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.2,0.3],[0.3,0.4],[0.7,0.8])
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_2	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.8,0.9],[0.1,0.2],[0.1,0.2])
A_3	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.1,0.3],[0.1,0.2],[0.8,0.9])
A_4	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.6,0.7],[0.4,0.5],[0.3,0.4])
A_5	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_6	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.6,0.7],[0.4,0.5],[0.3,0.4])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])
A_7	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.4,0.5],[0.5,0.6],[0.5,0.6])
A_8	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.8,0.9],[0.1,0.2],[0.1,0.2])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.3,0.4],[0.4,0.5],[0.6,0.7])
A_9	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.1,0.3],[0.1,0.2],[0.8,0.9])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.5,0.5],[0.6,0.7],[0.4,0.5])	([0.5,0.6],[0.5,0.6],[0.4,0.5])
A_{10}	([0.4,0.5],[0.5,0.6],[0.5,0.6])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.2,0.3],[0.3,0.4],[0.7,0.8])	([0.3,0.4],[0.4,0.5],[0.6,0.7])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.7,0.8],[0.2,0.3],[0.2,0.3])	([0.6,0.7],[0.4,0.5],[0.3,0.4])

A. We build the two-decision matrix with seven criteria and ten alternatives and put then into one matrix using the neutrosophic numbers as shown in Table 1. These numbers are converted to the crisp values and combined into one matrix.

B. Eqs. (5 and 6) are used to normalize the decision matrix as shown in Table 2. All criteria in this study are positive criteria. Then we subtract each value in the decision matrix by the minimum value and then divide it by difference between the maximum and minimum value.

Table 2. Normalized Decision Matrix Representation

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	0.407407	0.121951	0.159091	0.537594	0.456311	0.582278	0.699187
A_2	0.562963	0.463415	0.363636	0.590226	0.834951	0.827004	1
A_3	0	0.987805	1	0.992481	0	0.932489	0
A_4	0.248148	0.695122	0.318182	0.406015	0.375405	0.915612	0.314363
A_5	1	0.670732	0.375	0.556391	0.770227	0.181435	0.249322
A_6	0.381481	0.788618	0.44697	1	0.339806	0.476793	0.539295
A_7	0.318519	0.174797	0.473485	0.511278	0.352751	0	0.233062
A_8	0.214815	1	0.382576	0.447368	0.38835	0.063291	0.246612
A_9	0.225926	0	0.386364	0.432331	0.495146	0.156118	0.376694

A_{10}	0.248148	0.292683	0	0	1	1	0.506775

C. Eqs. (7,8, and 9) are used to compute the median matrix.

D. The criteria weights are computed as shown in Table 3.

Table 3. Criteria Weights Representation

	WEIGHT	RANK
C_1	0.142156	5
C_2	0.135014	1
C_3	0.137295	2
C_4	0.148696	6
C_5	0.14022	4
C_6	0.156914	7
C_7	0.139704	3

E. The weighted normalized decision matrix is computed as shown in Table 4.

Table 4. Weighted normalized decision matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	0.057916	0.016465	0.021842	0.079938	0.063984	0.091368	0.097679
A_2	0.080029	0.062568	0.049925	0.087764	0.117077	0.129769	0.139704
A_3	0	0.133368	0.137295	0.147578	0	0.146321	0
A_4	0.035276	0.093851	0.043685	0.060373	0.052639	0.143673	0.043918
A_5	0.142156	0.090558	0.051485	0.082733	0.108001	0.02847	0.034831
A_6	0.05423	0.106475	0.061367	0.148696	0.047648	0.074816	0.075342
A_7	0.045279	0.0236	0.065007	0.076025	0.049463	0	0.03256
A_8	0.030537	0.135014	0.052526	0.066522	0.054454	0.009931	0.034453
A_9	0.032117	0	0.053046	0.064286	0.069429	0.024497	0.052626
A_{10}	0.035276	0.039516	0	0	0.14022	0.156914	0.070798

F. Then we ranked the alternatives as shown in Table 5.

Table 5. Ranking of Alternatives

	RANK
A_1	4
A_2	10
A_3	8
A_4	6
A_5	7
A_6	9
A_7	1
A_8	3
A_9	2
A_{10}	5

4.1 Analysis of Results and Comparative Discussion

The evaluation of university English teaching quality is a critical aspect of ensuring effective learning outcomes for students. English, as a global language, plays a pivotal role in academic, professional, and social environments. Therefore, assessing the quality of English education in universities is essential to ensure students acquire the necessary language skills to meet real-world demands. This evaluation involves analyzing various factors, including teaching methods, curriculum design, teacher performance, and student engagement. One of the most important indicators of teaching quality is the effectiveness of teaching methods. Innovative and interactive teaching techniques, such as group discussions, role-playing, and project-based learning, allow students to actively participate and practice their language skills.

A departure from traditional lecture-based approaches to more student-centered methods can significantly improve learning outcomes. Additionally, incorporating technology, such as language learning apps, multimedia tools, and online resources, can enhance the teaching process. Curriculum design is another key factor in evaluating teaching quality. A well-structured curriculum should balance the four core language skills: reading, writing, listening, and speaking. It should also integrate cultural and practical elements to help students understand and use English in real-life scenarios.

Regular updates to the curriculum based on global trends and industry needs are essential to keep it relevant and effective. Teacher performance also greatly influences teaching quality. Effective English teachers possess not only subject knowledge but also the ability to motivate and inspire students. Their communication skills, teaching style, and ability to provide constructive feedback are crucial in fostering a positive learning environment.

Continuous teacher training and professional development programs can help educators stay updated with modern teaching strategies and methodologies. Student engagement is another critical component of the evaluation process. Active participation in class activities, completion of assignments, and willingness to communicate in English are indicators of successful teaching. Feedback from students through surveys and discussions can provide valuable insights into areas that require improvement.

Finally, evaluating university English teaching quality involves a comprehensive analysis of teaching methods, curriculum design, teacher performance, and student engagement. By addressing these aspects, universities can ensure that their English programs equip students with the necessary language skills to excel in their academic and professional pursuits. Continuous evaluation and improvement of teaching quality are vital for meeting the evolving demands of English education in a globalized world.

4.2 Sensitivity Analysis

This section shows the Sensity analysis under different values. In this study, we proposed eight cases by changing the criteria weights. First, we proposed all criteria have the same weight. Then we proposed one criterion that has 20% weights and others have the same weight. Table 6 shows the different criteria for weights.

Then we applied the proposed method under different weights. Then we rank the alternatives. We show the proposed methos rank is stable under different weights. Table 7 shows the rank of alternatives under different weights.

Table 6. The different criteria weights.

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
C_1	0.142857	0.2	0.133333	0.133333	0.133333	0.133333	0.133333	0.133333
C_2	0.142857	0.133333	0.2	0.133333	0.133333	0.133333	0.133333	0.133333
C_3	0.142857	0.133333	0.133333	0.2	0.133333	0.133333	0.133333	0.133333
C_4	0.142857	0.133333	0.133333	0.133333	0.2	0.133333	0.133333	0.133333
C_5	0.142857	0.133333	0.133333	0.133333	0.133333	0.2	0.133333	0.133333
C_6	0.142857	0.133333	0.133333	0.133333	0.133333	0.133333	0.2	0.133333
C_7	0.142857	0.133333	0.133333	0.133333	0.133333	0.133333	0.133333	0.2

Table 7. The different rank of alternatives.

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
A_1	4	4	3	4	5	4	4	5
A_2	10	10	10	10	10	10	10	10
A_3	8	7	9	9	8	7	9	7
A_4	6	6	6	6	6	5	6	6
A_5	7	9	7	7	7	9	7	8
A_6	9	8	8	8	9	8	8	9
A_7	1	2	2	2	2	1	1	1
A_8	3	3	5	3	3	3	3	3
A_9	2	1	1	1	1	2	2	2
A_{10}	5	5	4	5	4	6	5	4

4.3. Comparative analysis

This section shows the comparative analysis between the proposed method and other MADM methods. We compared the proposed method with three different MAD methods under different frameworks such as fuzzy-CODAS, picture fuzzy-TOPSIS, triangular fuzzy-VIKOR. We show the proposed method is strong compared with other methods. Table 8 shows the comparative analysis results.

Table 8. The results of comparative analysis

	PROPOSE METHOD	FUZZY-CODAS	PICTURE FIZZY-TOPSIS	TRIANGULAR FUZZY-VIKOR
A_1	4	5	4	4
A_2	10	10	10	10
A_3	8	7	8	6
A_4	6	6	7	8
A_5	7	8	6	7
A_6	9	9	9	9
A_7	1	1	1	1
A_8	3	3	3	3
A_9	2	2	2	2
A_{10}	5	4	5	5

Table 9. Features of comparative results

	PROPOSE METHOD	FUZZY-CODAS	PICTURE FIZZY-TOPSIS	TRIANGULAR FUZZY-VIKOR
FRAMEWORK	Interval valued neutrosophic sets	Fuzzy sets	Picture fuzzy sets	Triangular fuzzy sets
TRUTHINESS	Yes	Yes	Yes	Yes
INDETERMINACY	Yes	No	No	No
FALSITY	Yes	Yes	Yes	Yes

Table 9 shows the features of the proposed method compared with other MADM methods. We show our method has an advantage to deal with uncertainty and value information compared with other methods.

From Table 8, it is evident that the ranking results of the three approaches show slight differences. However, all the models identify the same local comprehensive and applied university as the optimal choice and the same one as the worst. This consistency demonstrates that the INN-KEMIRA approach is both reasonable and effective in evaluating university English teaching quality.

The INN-KEMIRA approach possesses several valuable characteristics that make it a robust tool for decision-making. First, it can effectively capture both individual uncertainty and overall uncertainty within INNs. This allows the model to handle complex and uncertain information more accurately. Second, the INN- KEMIRA approach is characterized by a simple structure, clear physical meaning, and strong differentiation ability, which enhances its practical applicability.

Overall, the INN- KEMIRA approach offers a novel and effective solution for addressing multi-attribute decision-making problems under uncertainty. Its ability to balance simplicity, clarity, and differentiation makes it a powerful tool for evaluating and improving education quality management in higher education. By adopting the INN- KEMIRA approach, higher education institutions can ensure a more objective and accurate evaluation process, ultimately contributing to the enhancement of teaching quality and overall institutional performance.

5. Conclusion

The university English teaching quality evaluation is crucial for enhancing educational outcomes and ensuring students are equipped with essential language skills. English, as a global language, plays a vital role in academic, professional, and social contexts. A well-structured evaluation process helps identify strengths and weaknesses in teaching methods, curriculum design, and teacher performance, ensuring continuous improvement. By assessing teaching quality, universities can ensure that students develop proficiency in reading, writing, listening, and speaking, which are critical for their future careers and global communication. It also helps institutions align their teaching strategies with international standards and industry demands, making graduates more competitive. Moreover, evaluating teaching quality fosters accountability among educators and encourages the adoption of innovative, student-centered teaching methods. It also provides valuable feedback for curriculum updates, ensuring relevance to real-world applications. Ultimately, high-quality English education contributes to students' personal and professional development, benefiting both individuals and society. The university English teaching quality evaluation is viewed as the MADM. In this paper, the INN- KEMIRA approach is developed by integrating the KEMIRA method with INSs for handling MADM problems under uncertainty. This novel approach leverages the characteristics of INSs to effectively model uncertainty and imprecision in decision-making scenarios. Finally, a numerical example focusing on university English teaching quality evaluation is provided to demonstrate the practical application of the INN- KEMIRA approach. Additionally, comparative analyses are conducted to highlight the advantages and rationality of the proposed method.

Overall, this study offers a new framework for addressing MADM problems in uncertain environments, particularly in the context of education quality management. By extending the KEMIRA approach to INSs and combining it with the average method, the proposed INN- KEMIRA model provides a systematic, accurate, and reliable solution for complex decision-making tasks. The demonstrated application in university English teaching quality evaluation highlights its potential for broader use in similar fields.

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