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An Effective Neutrosophic Approach for Group Decision-Making in College English Teaching Quality Evaluation

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Abstract: College English holds great importance in Chinese universities as one of the largest, most influential, and highly regarded foundational courses. Despite significant progress in reforming college English teaching (CET), its effectiveness has faced widespread criticism. To ensure and enhance the quality of CET, it is essential to explore the establishment of a quality evaluation mechanism. One such mechanism is the multiple-attribute group decision-making (MAGDM) approach. Recently, the Exponential TODIM (ExpTODIM) and TOPSIS techniques have been employed to address MAGDM challenges. To capture uncertain data during the evaluation process, interval neutrosophic sets (INSs) are administrated as a valuable tool. This study introduces the interval neutrosophic number Exponential TODIM-TOPSIS (INN-ExpTODIM-TOPSIS) approach to address MAGDM using INSs. Eventually, anumerical study for CET quality evaluation is administrated to validate the INN-ExpTODIM-TOPSIS approach for evaluating the quality of CET.

Keywords: Multiple-attribute group decision-making (MAGDM); Interval neutrosophic sets (INSs); ExpTODIM approach; TOPSIS approach; teaching quality evaluation

1. Introduction

1.1. Research background

College English is one of the largest, most influential, and widely valued basic courses among Chinese universities[1]. For a long time, while significant achievements have been made in the reform of CET, the teaching effectiveness of college English has also been widely criticized. Exploring the establishment of a quality monitoring mechanism for CET is the only way to ensure and improve the quality of CET. The construction of ateaching quality system can lay a solid foundation for applied talent cultivation, and only then cultivation of applied talents can be effectively operated in universities. As teaching in universities gradually develops towards an application-oriented talent cultivation model, society's requirements for English talents are also becoming more diverse, with a greater emphasis on the practicality of English. The construction of aquality assurance system for CET has extremely important elements, including modules such as students, teachers, management, and evaluation[2, 3]. The roles and contents of these four modules are different, but they all lay the foundation for ensuring CET quality. In CET, teachers should understand the learning foundation of students, consider their learning characteristics in teaching, and carry out targeted teaching work. In the actual CET process, teachers should combine people-oriented and application-oriented talent cultivation models, and build a CET system on this basis. In the evaluation process, teachers should abandon the traditional teaching technique of only looking at grades, and instead set different evaluation standards based on the learning situation of different students [4]. For example, students with relatively poor English foundations have slightly lower evaluation standards for teachers, while students with strong English foundations have relatively higher evaluation standards for teachers. In addition, it is necessary to build the content of daily learning performance to enrich the structure of evaluation system and make the English teaching evaluation more objective [5]. Through this approach, students with poor English foundations can establish confidence in learning English during the learning process, while students with better grades can make better progress, laying a solid foundation for them to become applied English talents[6]. The study of English courses in universities is aimed at enabling students to use the English language, which is also a need for applied talents in society. Therefore, teachers can use diverse techniques to evaluate the learning outcomes of students during the teaching process. If only quantitative teaching techniques are utilized in the evaluation process to evaluate student learning, it lacks a certain degree of objectivity. Teaching itself is a complex task, and in order to make teaching evaluation more objective, it is necessary to combine qualitative and quantitative evaluation techniques, with qualitative evaluation as the main focus and quantitative evaluation as a supplement. Qualitative evaluation is usually influenced by human factors, but quantitative evaluation is more objective. So, only by combining these two evaluation techniques can the evaluation of CET be more reasonable. In addition, we can also start from two aspects: formative evaluation and summative evaluation. Summative evaluation refers to the mid-term and final exams of a semester. However, the process of students learning English is dynamic, and if only the results are emphasized in evaluation, it is impossible to objectively evaluate the learning situation of college students. Therefore, self-evaluation or peer evaluation can also be utilized in the evaluation. Combining these two evaluation techniques to form a comprehensive evaluation system for CET, cultivating students' English proficiency.

1.2. Research objectives

With the increasing complexity in decision-making, relying solely on personal information often falls short of ensuring high-quality outcomes [7, 8]. GDM enhances the decision-making process by pooling the expertise of professionals from diverse fields, leveraging a broader range of knowledge to ensure more scientifically sound decisions [9, 10]. Additionally, GDM facilitates consensus among decision-makers, promoting smoother implementation of decisions [11, 12]. As a result, GDM is widely utilized across various socio-economic sectors, offering robust support for tackling complex decision-making challenges. Essentially, GDM involves engaging multiple decision-makers to assess available options and choose the best solution [13]. In the evaluation process, in order to characterize the fuzzy data in GDM problems, Zadeh [14] put forward fuzzy sets (FSs) in 1965. With the continuous deepening and expansion of theoretical and applied research, fuzzy sets gradually encounter some unavoidable defects in problem-solving. Therefore, scholars have extended many new forms to express uncertain information, such as linguistic Pythagorean FSs [15, 16], probabilistic hesitant FSs [17-19] and interval neutrosophic sets (INSs) [20]. As the extension form of FSs, key characteristic of INSs is that truth-membership (TM), indeterminacy-membership (IM) and falsity-membership (FM) are interval values, making them more flexible in dealing with uncertainty [21, 22]. The academic community has conducted extensive research on MAGDM problems based on INSs, and has made significant progress in similarity measurement, aggregation techniques, and score functions. The above research provides reliable techniques and ideas for solving MAGDM problems in INSs environments, but there are also some limitations: it ignores GDM problems driven by decision-maker behavior, and research on social network relationships in decision-making environments is not yet complete. The CET quality evaluation is MAGDM. In addressing MAGDM challenges, researchers have recently turned to the ExpTODIM technique [10, 23] and TOPSIS [24]. These methods have proven useful in managing MAGDM issues. To capture uncertain data during the CET quality evaluation, INSs [20] are administrated as a valuable tool. This paper introduces the INN-ExpTODIM-TOPSIS approach, specifically designed to put forward MAGDM under INSs. To validate the effectiveness of the proposed technique, a numerical study focusing on CET quality evaluation is conducted. Recently, the ExpTODIM technique [10, 23] and TOPSIS [24] were put forward MAGDM. The INSs [20] are put forward characterizing uncertain data during the CET quality evaluation. In this study, the INN-ExpTODIM-TOPSIS technique is designed to put forward MAGDM under INSs. Eventually, anumerical study for CET quality evaluation is administrated to validate the INN-ExpTODIM-TOPSIS technique.

The study is structured as follows. Section 2 provides an overview of INSs. Section 3 presents the INN-ExpTODIM-TOPSIS technique, which is specifically tailored for INSs using the entropy technique. In Section 4, anumerical study is presented, focusing on CET quality evaluation along with a comparative analysis. Finally, Section 5 concludes this study.

2. Preliminaries

Wang et al. [25] addressed the SVNSs

Definition 1 [25]. The SVNSs is characterized:

$$WA = \left\{ \left(x, WT_A(x), WI_A(x), WF_A(x) \right) \middle| x \in \Phi \right\} \tag{1}$$

where the $WT_A(x), WI_A(x), WF_A(x)$ depicts the TM, IM and FM, $WT_A(x), WI_A(x), WF_A(x) \in [0,1]$ and satisfies $0 \le WT_A(x) + WI_A(x) + WF_A(x) \le 3$.

Wang et al.[20] addressed the INSs.

Definition 2[20]. The INSs is administrated:

$$WA=\left\{\left(\phi,WT_A(\phi),WI_A(\phi),WF_A(\phi)\right)\middle|\phi\in\Phi\right\} \quad (2)$$

where the $WT_A(\phi),WI_A(\phi),WF_A(\phi)$ depicts the TM, IM and FM, $WT_A(\phi),WI_A(\phi),WF_A(\phi)\subseteq[0,1]$ and satisfies $0\le \sup WT_A(\phi)+\sup WI_A(\phi)+\sup WF_A(\phi)\le 3$.

The INN (interval neutrosophic number) is denoted : $WA=(WT_A,WI_A,WF_A)=([WTL_A,WTR_A],[WIL_A,WIR_A],[WFL_A,WFR_A])$, where $WT_A,WI_A,WF_A\subseteq[0,1]$, and $0\le WTR_A+WIR_A+WFR_A\le 3$.

Definition 3 [26]. Let $WA=([WTL_A,WTR_A],[WIL_A,WIR_A],[WFL_A,WFR_A])$ be INN, score value is administrated:

$$WSV(WA)=\frac{\begin{pmatrix}(2+WTL_A-WIL_A-WFL_A)\\+(2+WTR_A-WIR_A-WFR_A)\end{pmatrix}}{6},\ WSV(SA)\in[0,1]. \quad (3)$$

Definition 4[26]. Let $WA=([WTL_A,WTR_A],[WIL_A,WIR_A],[WFL_A,WFR_A])$ be INN, accuracy value is administrated:

$$WAV(WA)=\frac{2+(WTL_A+WTR_A)-(WFL_A+WFR_A)}{4},\ WAV(WA)\in[0,1]\ . \quad (4)$$

Huang et al. [27] administrated the order under INNs.

Definition 5[26]. Let $WA=([WTL_A,WTR_A],[WIL_A,WIR_A],[WFL_A,WFR_A])$ and $WB=([WTL_B,WTR_B],[WIL_B,WIR_B],[WFL_B,WFR_B])$ be INNs,

$$WSV(WA)=\frac{\begin{pmatrix}(2+WTL_A-WIL_A-WFL_A)\\+(2+WTR_A-WIR_A-WFR_A)\end{pmatrix}}{6}$$ and

$$WSV(WB)=\frac{\begin{pmatrix}(2+WTL_B-WIL_B-WFL_B)\\+(2+WTR_B-WIR_B-WFR_B)\end{pmatrix}}{6}$$, and

$$WAV(WA)=\frac{2+(WTL_A+WTR_A)-(WFL_A+WFR_A)}{4}$$ and

$$WAV(WB)=\frac{2+(WTL_B+WTR_B)-(WFL_B+WFR_B)}{4}$$, then if $WSV(WA)<WSV(WB)$, then $WA<WB$; if $WSV(WA)=WSV(WB)$, then (1) if $WAV(WA)=WAV(WB)$, then $WA=WB$; (2) if $WAV(WA)<WAV(WB)$, then $WA<WB$.

Definition 6[28]. Let $WA=\left(\left[WTL_A,WTR_A\right],\left[WIL_A,WIR_A\right],\left[WFL_A,WFR_A\right]\right)$ and $WB=\left(\left[WTL_B,WTR_B\right],\left[WIL_B,WIR_B\right],\left[WFL_B,WFR_B\right]\right)$ be INNs, different operations are administrated:

$$(1)\ WA\oplus WB=\begin{pmatrix}\left(WTL_A+WTL_B-WTL_AWTL_B,WTR_A+WTR_B-WTR_AWTR_B\right),\\ \left[WIL_AWIL_B,WIR_AWIR_B\right],\left[WFL_AWFL_B,WFR_AWFR_B\right]\end{pmatrix};$$

$$(2)\ WA\otimes WB=\begin{pmatrix}\left[WTL_AWTL_B,WTR_AWTR_B\right],\\ \left[WIL_A+WIL_B-WIL_AWIL_B,WIR_A+WIR_B-WIR_AWIR_B\right],\\ \left[WFL_A+WFL_B-WFL_AWFL_B,WFR_A+WFR_B-WFR_AWFR_B\right]\end{pmatrix};$$

$$(3)\ \xi WA=\begin{pmatrix}\left[1-\left(1-WTL_A\right)^{\xi},1-\left(1-WTR_A\right)^{\xi}\right],\\ \left[\left(WIL_A\right)^{\xi},\left(WIR_A\right)^{\xi}\right],\left[\left(WFL_A\right)^{\xi},\left(WFR_A\right)^{\xi}\right]\end{pmatrix},\xi>0;$$

$$(4)\ \left(WA\right)^{\lambda}=\begin{pmatrix}\left[\left(WTL_A\right)^{\xi},\left(WTR_A\right)^{\xi}\right],\left[\left(WIL_A\right)^{\xi},\left(WIR_A\right)^{\xi}\right],\\ \left[1-\left(1-WFL_A\right)^{\xi},1-\left(1-WFR_A\right)^{\xi}\right]\end{pmatrix},\xi>0.$$

Definition 7[29]**.** Let $WA=\left(\left[WTL_A,WTR_A\right],\left[WIL_A,WIR_A\right],\left[WFL_A,WFR_A\right]\right)$ and $WB=\left(\left[WTL_B,WTR_B\right],\left[WIL_B,WIR_B\right],\left[WFL_B,WFR_B\right]\right)$, then INNHD (INN Hamming distance) is administrated:

$$INNHD\left(WA,WB\right)=\frac{1}{6}\begin{pmatrix}\left|WTL_A-WTL_B\right|+\left|WTR_A-WTR_B\right|+\left|WIL_A-WIL_B\right|+\\ \left|WIR_A-WIR_B\right|+\left|WFL_A-WFL_B\right|+\left|SFR_A-WFR_B\right|\end{pmatrix} \quad (5)$$

The INNWA and INNWG approach [28] are administrated:

Definition 8[28]. Let $WA_j=\left(\left[WTL_j,WTR_j\right],\left[WIL_j,WIR_j\right],\left[WFL_j,WFR_j\right]\right)$ be INNs, INNWA approach is administrated:

$$\begin{aligned}&\text{INNWA}\left(WA_1,WA_2,\ldots,WA_n\right)\\ &=ww_1WA_1\oplus ww_2WA_2\ldots\oplus ww_nWA_n=\overset{n}{\underset{j=1}{\oplus}}ww_jWA_j\\ &=\begin{pmatrix}\left[1-\prod_{j=1}^{n}\left(1-WTL_{ij}\right)^{ww_j},1-\prod_{j=1}^{n}\left(1-WTR_{ij}\right)^{ww_j}\right],\\ \left[\prod_{k=1}^{l}\left(WFL_{ij}^{k}\right)^{ww_j},\prod_{k=1}^{l}\left(WFR_{ij}^{k}\right)^{ww_j}\right],\\ \left[\prod_{k=1}^{l}\left(WTL_{ij}^{k}\right)^{ww_j},\prod_{k=1}^{l}\left(WTR_{ij}^{k}\right)^{ww_j}\right]\end{pmatrix}\end{aligned} \quad (6)$$

where $ww=\left(ww_1,ww_2,...,ww_n\right)^T$ be weight numbers of WA_j, $ww_j>0,\sum_{j=1}^{n}ww_j=1.$

Definition 9[28]. Let $WA_j = \left(\left[WTL_j, WTR_j\right], \left[WIL_j, WIR_j\right], \left[WFL_j, WFR_j\right]\right)$ be INNs, INNWG approach is conducted:

$$\begin{aligned}
&\text{INNWG}\left(WA_1, WA_2, \ldots, WA_n\right) \\
&= \left(WA_1\right)^{ww_1} \otimes \left(WA_2\right)^{ww_2}, \ldots \otimes \left(WA_n\right)^{ww_n} = \underset{j=1}{\overset{n}{\otimes}} \left(WA_j\right)^{ww_j} \\
&= \begin{pmatrix}
\left[\prod_{j=1}^{n}\left(WTL_{ij}\right)^{ww_j}, \prod_{j=1}^{n}\left(WTR_{ij}\right)^{ww_j}\right], \\
\left[1-\prod_{k=1}^{l}\left(1-WFL_{ij}^{k}\right)^{ww_j}, 1-\prod_{k=1}^{l}\left(1-WFR_{ij}^{k}\right)^{ww_j}\right], \\
\left[1-\prod_{k=1}^{l}\left(1-WTL_{ij}^{k}\right)^{ww_j}, 1-\prod_{k=1}^{l}\left(1-WTR_{ij}^{k}\right)^{ww_j}\right]
\end{pmatrix}
\end{aligned} \tag{7}$$

where $ww = \left(ww_1, ww_2, ..., ww_n\right)^T$ be weight numbers of WA_j, $ww_j > 0, \sum_{j=1}^{n} ww_j = 1.$

3. INN-ExpTODIM-TOPSIS approach for MAGDM with entropy

3.1. INN-GDM problem description

The INN-ExpTODIM-TOPSIS approach is addressed for MAGDM. Let $WA = \left\{WA_1, WA_2, \cdots, WA_m\right\}$ be alternatives, and attributes set $WG = \left\{WG_1, WG_2, \cdots, WG_n\right\}$ with weight $s\omega$, where $s\omega_j \in [0,1]$, $\sum_{j=1}^{n} s\omega_j = 1$ and invited experts $WE = \left\{WE_1, WE_2, \cdots, WE_q\right\}$ with expert's weight sw, where $sw_j \in [0,1]$, $\sum_{j=1}^{n} sw_j = 1$.

Then, INN-ExpTODIM-TOPSIS approach is addressed for MAGDM.

Step 1. Address the group INN-matrix $WR^t = \left[WR_{ij}^t\right]_{m\times n} = \left(\left[WTL_{ij}^t, WTR_{ij}^t\right], \left[WIL_{ij}^t, WIR_{ij}^t\right], \left[WFL_{ij}^t, WFR_{ij}^t\right]\right)_{m\times n}$ and average INN-matrix $WR = \left[WR_{ij}\right]_{m\times n}$:

$$WR^t = \left[WR_{ij}^t\right]_{m\times n} = \begin{array}{c} \\ WA_1 \\ WA_2 \\ \vdots \\ WA_m \end{array} \begin{array}{c} \begin{array}{cccc} WG_1 & WG_2 & \ldots & WG_n \end{array} \\ \begin{bmatrix} WR_{11}^t & WR_{12}^t & \ldots & WR_{1n}^t \\ WR_{21}^t & WR_{22}^t & \ldots & WR_{2n}^t \\ \vdots & \vdots & \vdots & \vdots \\ WR_{m1}^t & WR_{m2}^t & \ldots & WR_{mn}^t \end{bmatrix} \end{array} \tag{8}$$

$$WR=\left[WR_{ij}\right]_{m\times n}=\begin{matrix} & WG_1 & WG_2 & \dots & WG_n \\ WA_1 & WR_{11} & WR_{12} & \dots & WR_{1n} \\ WA_2 & WR_{21} & WR_{22} & \dots & WR_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ WA_m & WR_{m1} & WR_{m2} & \dots & WR_{mn} \end{matrix} \quad (9)$$

In line with INNWA technique, the $WR=\left(\left[WTL_{ij},WTR_{ij}\right],\left[WIL_{ij},WIR_{ij}\right],\left[WFL_{ij},WFR_{ij}\right]\right)_{m\times n}$ is:

$$WR_{ij}=sw_1WR_{ij}^1\oplus sw_2WR_{ij}^2\oplus\cdots\oplus sw_tWR_{ij}^t$$
$$=\begin{pmatrix}\left[1-\prod_{k=1}^{t}\left(WTL_{ij}^t\right)^{sw_j},1-\prod_{k=1}^{t}\left(WTR_{ij}^t\right)^{sw_j}\right],\\ \left[\prod_{k=1}^{t}\left(WFL_{ij}^t\right)^{sw_j},\prod_{k=1}^{t}\left(WFR_{ij}^t\right)^{sw_j}\right],\\ \left[\prod_{k=1}^{t}\left(1-WTL_{ij}^t\right)^{sw_j},\prod_{k=1}^{t}\left(1-WTR_{ij}^t\right)^{sw_j}\right]\end{pmatrix} \quad (10)$$

Step 2. Normalize the $WR=\left[WR_{ij}\right]_{m\times n}$ into $NWR=\left[NWR_{ij}\right]_{m\times n}$.

For benefit attributes:

$$NWR_{ij}=\begin{pmatrix}\left[NWTL_{ij},NWTR_{ij}\right],\\ \left[NWIL_{ij},NWIR_{ij}\right],\left[NWFL_{ij},NWFR_{ij}\right]\end{pmatrix}$$
$$=WR_{ij}=\begin{pmatrix}\left[WTL_{ij},WTR_{ij}\right],\\ \left[WIL_{ij},WIR_{ij}\right],\left[WFL_{ij},WFR_{ij}\right]\end{pmatrix} \quad (11)$$

For cost attributes:

$$NWR_{ij}=\begin{pmatrix}\left[NWTL_{ij},NWTR_{ij}\right],\\ \left[NWIL_{ij},NWIR_{ij}\right],\left[NWFL_{ij},NWFR_{ij}\right]\end{pmatrix}$$
$$=WR_{ij}=\begin{pmatrix}\left[WFL_{ij},WFR_{ij}\right],\\ \left[WIL_{ij},WIR_{ij}\right],\left[WTL_{ij},WTR_{ij}\right]\end{pmatrix} \quad (12)$$

3.2. Administrate the attributes weight through entropy.

Entropy approach [30] is useful tool to administrate the weight. The normalized INN values (NINNV) are conducted:

$$NINNV_{ij} = \frac{\dfrac{WAV\left(\left[NWTL_{ij}, NWTR_{ij}\right],\left[NWIL_{ij}, NWIR_{ij}\right],\left[NWFL_{ij}, NWFR_{ij}\right]\right)}{WSV\left(\left[NWTL_{ij}, NWTR_{ij}\right],\left[NWIL_{ij}, NWIR_{ij}\right],\left[NWFL_{ij}, NWFR_{ij}\right]\right)}}{\sum_{i=1}^{m}\left(\dfrac{WAV\left(\left[NWTL_{ij}, NWTR_{ij}\right],\left[NWIL_{ij}, NWIR_{ij}\right],\left[NWFL_{ij}, NWFR_{ij}\right]\right)}{WSV\left(\left[NWTL_{ij}, NWTR_{ij}\right],\left[NWIL_{ij}, NWIR_{ij}\right],\left[NWFL_{ij}, NWFR_{ij}\right]\right)}\right)}, \tag{13}$$

The uncertain fuzzy Shannon entropy (UFSE) is conducted:

$$UFSE_j = -\frac{1}{\ln m}\sum_{i=1}^{m} NINNV_{ij} \ln NINNV_{ij} \tag{14}$$

and $NINNDM_{ij} \ln NINNDM_{ij} = 0$ if $NINNDM_{ij} = 0$.

Then, the weight information is conducted:

$$s\omega_j = \frac{1 - UFSE_j}{\sum_{j=1}^{n}\left(1 - UFSE_j\right)} \tag{15}$$

3.3. INN-ExpTODIM-TOPSIS approach for MAGDM

INN-ExpTODIM-TOPSIS approach is addressed for MAGDM.

(1) Address the relative weight numbers:

$$rs\omega_j = s\omega_j \Big/ \max_j s\omega_j, \tag{16}$$

(2) The INN uncertain dominance degree (INNUDD) of SA_i over SA_t for SG_j is addressed:

$$INNUDD_j\left(WA_i, WA_t\right) = \begin{cases} \dfrac{rsw_j \times \left(1 - 10^{-\rho INNHD\left(NWR_{ij}, NWR_{tj}\right)}\right)}{\sum_{j=1}^{n} rsw_j} & if\ WSV\left(NWR_{ij}\right) > WSV\left(NWR_{tj}\right) \\ 0 & if\ WSV\left(NWR_{ij}\right) = WSV\left(NWR_{tj}\right) \\ -\dfrac{1}{\pi}\dfrac{\sum_{j=1}^{n} rsw_j \times \left(1 - 10^{-\rho INNHD\left(NWR_{ij}, NWR_{tj}\right)}\right)}{rsw_j} & if\ WSV\left(NWR_{ij}\right) < WSV\left(NWR_{tj}\right) \end{cases} \tag{17}$$

where ρ is conducted from Tversky and Kahneman [31] and $\pi \in [1,5]$ [32].

The $INNUDD_j\left(WA_i\right)\left(j = 1, 2, 3, \cdots, n\right)$ for WG_j is addressed:

$$INNUDD_j\left(WA_i\right)=\left[INNUDD_j\left(WA_i,WA_t\right)\right]_{m\times m}$$

$$=\begin{array}{c} \\ WA_1 \\ WA_2 \\ \vdots \\ WA_m \end{array}\begin{array}{c} \begin{matrix} WA_1 & WA_2 & \cdots & WA_m \end{matrix} \\ \begin{bmatrix} 0 & INNUDD_j\left(WA_1,WA_2\right) & \cdots & INNUDD_j\left(WA_1,WA_m\right) \\ INNUDD_j\left(WA_2,WA_1\right) & 0 & \cdots & INNUDD_j\left(WA_2,WA_m\right) \\ \vdots & \vdots & \cdots & \vdots \\ INNUDD_j\left(WA_m,WA_1\right) & INNUDDD_j\left(WA_m,WA_2\right) & \cdots & 0 \end{bmatrix} \end{array}$$

(3) Address the overall INNUDD of WA_i over other alternatives for WG_j :

$$INNUDD_j\left(WA_i\right)=\sum_{t=1}^{m} INNUDD_j\left(WA_i,WA_t\right) \tag{18}$$

The overall INNDDD is conducted:

$$INNDDD=\left(INNDDD_{ij}\right)_{m\times n}$$

$$=\begin{bmatrix} & WG_1 & WG_2 & \cdots & WG_n \\ WA_1 & \sum_{t=1}^{m} INNDDD_1\left(WA_1,WA_t\right) & \sum_{t=1}^{m} INNDDD_2\left(WA_1,WA_t\right) & \cdots & \sum_{t=1}^{m} INNDDD_n\left(WA_1,WA_t\right) \\ WA_2 & \sum_{t=1}^{m} INNDDD_1\left(WA_2,WA_t\right) & \sum_{t=1}^{m} INNDDD_2\left(WA_2,WA_t\right) & \cdots & \sum_{t=1}^{m} INNDDD_n\left(WA_2,WA_t\right) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ WA_m & \sum_{t=1}^{m} INNDDD_1\left(WA_m,WA_t\right) & \sum_{t=1}^{m} INNDDD_2\left(WA_m,WA_t\right) & \cdots & \sum_{t=1}^{m} INNDDD_n\left(WA_m,WA_t\right) \end{bmatrix} \tag{19}$$

(4) Address the INNPIDS (INN positive ideal decision solution) and INNNIDS (INN negative ideal decision solution):

$$INNPIDS=\left(INNPIDS_1,INNPIDS_1,\cdots,INNPIDS_n\right) \tag{20}$$

$$INNNIDS=\left(INNNIDS_1,INNNIDS_1,\cdots,INNNIDS_n\right) \tag{21}$$

$$INNPIDS_j=\max_{j=1}^{n} INNDDD_{ij}, \tag{22-a}$$

$$INNNIDS_j=\min_{j=1}^{n} INNDDD_{ij} \tag{22-b}$$

(5) Address the INNED (INN Euclidean distance) and INNCC (INN closeness coefficient) from INNPIDS. The choice has the maximum INNCC is optimal choice.

$$INNED\left(WA_i,INNPIDS\right)=\sqrt{\sum_{j=1}^{n}\left(INNDDD_{ij}-INNPIDS_j\right)^2} \tag{23}$$

$$INNED\left(WA_i,INNNIDS\right)=\sqrt{\sum_{j=1}^{n}\left(INNDDD_{ij}-INNNIDS_j\right)^2} \tag{24}$$

$$INNCC\left(WA_i,INNPIDS\right)=\frac{INNED\left(WA_i,INNNIDS\right)}{INNED\left(WA_i,INNPIDS\right)+INNED\left(WA_i,INNPIDS\right)} \tag{25}$$

4. Quantitative Illustration and Comparative Evaluation

4.1. Quantitative Illustration

Teaching quality evaluation encompasses a comprehensive assessment of teachers' proficiency, instructional methods, attitudes, and other relevant aspects. Presently, numerous universities employ diverse approaches to evaluate theteaching quality of their faculty. Typically, such evaluations are conducted at the end of this semester, with students providing online feedback on one or more courses taught by the teacher. Alternatively, teaching supervisors or specialized departments within the institution may observe a teacher's classroom at specific intervals during the semester to gain insights into their teaching practices. To enhance the quality of CET further, continuous improvements in the curriculum system are necessary. The foundation of this curriculum system lies in the evaluation system for CET. Hence, there is a need to develop a comprehensive, practical, scientific, and objective quality evaluation management system. A teaching philosophy underlying this system revolves around prioritizing students as the primary beneficiaries, teachers as the driving force, industry feedback, and industry-specific guidance. Therefore, while constructing a quality evaluation system for CET, the following two aspects should be considered: (1) Student-Centered Approach: Regardless of changes in teaching formats, students always play a central role in the teaching process. In college English courses, students actively participate in the learning experience. (2) Teacher Leadership: Teachers have a pivotal role in college English courses, indicating the course's practicality. Consequently, teachers can adapt teaching techniques and approaches based on the classroom dynamics and instructional context. By integrating students' theoretical knowledge and practical abilities while enhancing their overall development, teachers have relatively more freedom in guiding the college English curriculum. If all evaluation systems solely focus on assessing teachers' classroom performance, the inherent communicative and interactive functions of the English language may be compromised. Therefore, this requires teachers to provide support and encouragement to students in English learning outside of the classroom. The implementation of practical activities mainly relies on extracurricular activities, which in turn can promote the understanding of classroom theory. Therefore, the teaching quality evaluation must adhere to the unity of theory and practice. With continuous maturity and development of internet application technology, big data is also increasingly being applied to teaching evaluation. At the end of each semester or during a certain period of study, the school will organize students to evaluate teachers on the official account or App at the specified time. If the evaluation cannot be completed on time, students will not be able to check their grades and perform other operations. This characteristic of short time and heavy tasks can make students perfunctory in evaluating, resulting in teachers receiving feedback that has no reference value. This kind of "evaluating teaching for the sake of evaluation" ultimately only allows evaluation to become a formality. The quality evaluation of CET mainly targets the teaching of teachers. However, there are relatively few experts specialized in this field in China. Therefore, the current evaluation system mainly introduces Western theories and research techniques, but in reality, it does not fully meet the requirements of China's CET quality evaluation system. The lack of empirical research has led to the lack of guarantee for the scientificity of various evaluation indicators and the effectiveness of results, let alone the goal of improving the evaluation system in the long run. The CET quality evaluation is MAGDM. Five potential local-applied undergraduate colleges and universities are chosen in lightw ith four attributes: WG_1 is CET contents; WG_2 is CET costs; ③WG_3 is CET satisfaction degree; ④WG_4 is c CET means. The CET costs (WG_2) is a cost attribute. Five possible local-applied undergraduate colleges and universities are evaluated with linguistic scales through four criteria under three experts $WE^t\ (t=1,2,3)$ with expert's weight $(0.32, 0.40, 0.28)$. Table 1 is referenced from Ref.[33].

Table 1. Linguistic scales and INNs

Linguistic scales	INNs
Exceedingly Terrible-WET	([0.05,0.2], [0.6,0.7], [0.75,0.9])
Very Terrible-WVT	([0.15,0.3], [0.5,0.6], [0.65,0.8])
Terrible-WT	([0.25,0.4], [0.4,0.5], [0.55,0.7])
Medium-WM	([0.4,0.6], [0.1,0.2], [0.4,0.6])
Well-WW	([0.45,0.6], [0.3,0.4], [0.25,0.5])
Very Well-WVW	([0.65,0.8], [0.5,0.6], [0.15,0.3])
Exceedingly Well-WEW	([0.75,0.9], [0.6,0.7], [0.05,0.2])

The INN-ExpTODIM-TOPSIS approach is utilized to address the CET quality evaluation.

Step 1. Address the INN-matrix $WR^t = \left[WR_{ij}^t\right]_{5\times4} = \left(\left[WTL_{ij}^t, WTR_{ij}^t\right], \left[WIL_{ij}^t, WIR_{ij}^t\right], \left[WFL_{ij}^t, WFR_{ij}^t\right]\right)_{5\times4}$ (See Table 2-4).

Table 2. Evaluation data from WE_1

	WG1(benefit)	*WG2(cost)*	*WG3(benefit)*	*WG4(benefit)*
WA1	WVT	WM	WW	WVW
WA2	WM	WVT	WVT	WVW
WA3	WM	WT	WVW	WVT
WA4	WVT	WVW	WW	WM
WA5	WVW	WW	WM	WT

Table 3. Evaluation data from SE_2

	WG1(benefit)	*WG2(cost)*	*WG3(benefit)*	*WG4(benefit)*
WA1	WM	WT	WVW	WW

WA_2	WW	WVW	WVT	WT
WA_3	WM	WW	WT	WM
WA_4	WW	WVW	WT	WM
WA_5	WVT	WVT	WM	WW

Table 4. Evaluation data from SE_3

	WG_1(benefit)	WG_2(cost)	WG_3(benefit)	WG_4(benefit)
WA_1	WVW	WT	WVT	WM
WA_2	WM	WVW	WT	WW
WA_3	WVT	WM	WVW	WW
WA_4	WVT	WVW	WM	WW
WA_5	WVW	WW	WM	WT

Then according to INNWA technique, the $WR = \left[WR_{ij}\right]_{5\times4}$ is addressed (Table 5).

Table 5. The $WR = \left[WR_{ij}\right]_{5\times4}$

	WG_1	WG_2
WA_1	([0.71, 0.79], [0.34, 0.47], [0.45, 0.57])	([0.52, 0.63], [0.48, 0.53], [0.47, 0.58])
WA_2	([0.75, 0.82], [0.59, 0.69], [0.51, 0.53])	([0.64, 0.67], [0.54, 0.56], [0.42, 0.46])
WA_3	([0.76, 0.86], [0.46, 0.54], [0.48, 0.54])	([0.69, 0.72], [0.42, 0.49], [0.39, 0.42])
WA_4	([0.85, 0.94], [0.57, 0.69], [0.48, 0.62])	([0.76, 0.83], [0.38, 0.43], [0.43, 0.49])
WA_5	([0.63, 0.76], [0.59, 0.68], [0.39, 0.51])	([0.64, 0.71], [0.49, 0.52], [0.38, 0.43])
	WG3	WG4
WA_1	([0.66, 0.79], [0.54, 0.65], [0.46, 0.57])	([0.64, 0.79], [0.46, 0.57], [0.59, 0.68])
WA_2	([0.57, 0.64], [0.45, 0.54], [0.37, 0.56])	([0.63, 0.74], [0.37, 0.45], [0.56, 0.75])
WA_3	([0.63, 0.69], [0.47, 0.62], [0.48, 0.53])	([0.58, 0.79], [0.43, 0.54], [0.59, 0.64])
WA_4	([0.84, 0.92], [0.28, 0.35], [0.47, 0.54])	([0.78, 0.85], [0.35, 0.43], [0.56, 0.67])
WA_5	([0.63, 0.75], [0.45, 0.57], [0.45, 0.68])	([0.56, 0.64], [0.37, 0.49], [0.48, 0.59])

Step 2. Normalize the $WR = \left[WR_{ij}\right]_{5\times4}$ into $NWR = \left[NWR_{ij}\right]_{5\times4}$ (See Table 6).

Table 6. The $NWR = \left[NWR_{ij}\right]_{5\times4}$

	WG_1	WG_2
WA_1	([0.71, 0.79], [0.34, 0.47], [0.45, 0.57])	([0.47, 0.58], [0.48, 0.53], [0.52, 0.63])
WA_2	([0.75, 0.82], [0.59, 0.69], [0.51, 0.53])	([0.42, 0.46], [0.54, 0.56], [0.64, 0.67])
WA_3	([0.76, 0.86], [0.46, 0.54], [0.48, 0.54])	([0.39, 0.42], [0.42, 0.49], [0.69, 0.72])
WA_4	([0.85, 0.94], [0.57, 0.69], [0.48, 0.62])	([0.43, 0.49], [0.38, 0.43], [0.76, 0.83])
WA_5	([0.63, 0.76], [0.59, 0.68], [0.39, 0.51])	([0.38, 0.43], [0.49, 0.52], [0.64, 0.71])
	WG3	WG4
WA_1	([0.66, 0.79], [0.54, 0.65], [0.46, 0.57])	([0.64, 0.79], [0.46, 0.57], [0.59, 0.68])

WA2	([0.57, 0.64], [0.45, 0.54], [0.37, 0.56])	([0.63, 0.74], [0.37, 0.45], [0.56, 0.75])
WA3	([0.63, 0.69], [0.47, 0.62], [0.48, 0.53])	([0.58, 0.79], [0.43, 0.54], [0.59, 0.64])
WA4	([0.84, 0.92], [0.28, 0.35], [0.47, 0.54])	([0.78, 0.85], [0.35, 0.43], [0.56, 0.67])
WA5	([0.63, 0.75], [0.45, 0.57], [0.45, 0.68])	([0.56, 0.64], [0.37, 0.49], [0.48, 0.59])

Step 3. Address the weight numbers:
$s\omega_1 = 0.2301, s\omega_2 = 0.3322, s\omega_3 = 0.2210, s\omega_4 = 0.2167$.

Step 4. Address the relative weight numbers: $rs\omega = \{0.6927, 1.0000, 0.6653, 0.6523\}$.

Step 5. Address the $INNDDD = \left(NNDDD_{ij}\right)_{5\times4}$ (Table 7):

Table 7. The $INNDDD = \left(NNDDD_{ij}\right)_{5\times4}$

	WG1	*WG2*	*WG3*	*WG4*
WA1	-0.5280	-0.0445	-1.1254	-1.1279
WA2	0.2919	-0.5574	0.7572	-0.6242
WA3	-1.6551	0.4547	0.7824	-1.8264
WA4	-0.2255	0.8891	-0.4405	1.0735
WA5	0.2473	0.1913	-1.0016	-2.0332

Step 6. Address the INNPIDS and INNNIDS (Table 8).

Table 8. The INNPIDS and INNNIDS

	WG1	*WG2*	*WG3*	*WG4*
INNPIDS	0.2919	0.8891	0.7824	1.0735
INNNIDS	-1.6551	-0.5574	-1.1254	-2.0332

Step 7. Address the $\left(INNDDD_{ij} - INNPIDS_j\right)^2$ and $\left(INNDDD_{ij} - INNNIDS_j\right)^2$ (See table 9-10).

Table 9. The $\left(INNDDD_{ij} - INNPIDS_j\right)^2$

	WG1	*WG2*	*WG3*	*WG4*
WA1	0.6722	0.8717	3.6396	4.8462
WA2	0.0000	2.0924	0.0006	2.8823
WA3	3.7910	0.1887	0.0000	8.4096
WA4	0.2677	0.0000	1.4954	0.0000
WA5	0.0020	0.4870	3.1828	9.6513

Table 10. The $\left(INNDDD_{ij} - INNNIDS_j\right)^2$

	WG1	*WG2*	*WG3*	*WG4*

WA_1	1.2705	0.2631	0.0000	0.8195
WA_2	3.7910	0.0000	3.5441	1.9851
WA_3	0.0000	1.0244	3.6396	0.0427
WA_4	2.0440	2.0924	0.4691	9.6513
WA_5	3.6192	0.5605	0.0153	0.0000

Step 8. Address the $INNED(WA_i, INNPIDS)$, $INNED(WA_i, INNNIDS)$ and $INNCC(WA_i, INNPIDS)$ (See table 11-12).

Table 11. The $INNED(SA_i, INNPIS)$ and $INNED(SA_i, INNNIS)$

	$INNED(SA_i, INNPIS)$	$INNED(SA_i, INNNIS)$
WA_1	3.1670	1.5340
WA_2	2.2305	3.0529
WA_3	3.5198	2.1695
WA_4	1.3278	3.7758
WA_5	3.6501	2.0482

Table 12. The $INNCC(WA_i, INNPIDS)$ and order

	$INNCC(WA_i, INNPIDS)$	*Order*
WA_1	0.3263	5
WA_2	0.5778	2
WA_3	0.3813	3
WA_4	0.7398	1
WA_5	0.3594	4

Thus, the best local-applied undergraduate college and university is WA_4.

4.2. Comparative Evaluation

The INN-ExpTODIM-TOPSIS approach is compared with the INNWA approach [28] and INNWG approach [28], INN-VIKOR approach [34], INN-CODAS approach [35], INN-EDAS approach [33] and INN-TODIM approach [36]. The final comparative results are administrated in Table 13 and Figure 1.

Table 13. Order of different approaches

Approaches	*Order*
INNWA technique [28]	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$
INNWG technique[28]	$WA_4 > WA_2 > WA_5 > WA_3 > WA_1$
INN-VIKOR technique [34]	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$
INN-CODAS technique[35]	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$

INN-EDAS technique [33]	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$
INN-TODIM approach [36]	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$
INN-ExpTODIM-TOPSIS approach	$WA_4 > WA_2 > WA_3 > WA_5 > WA_1$

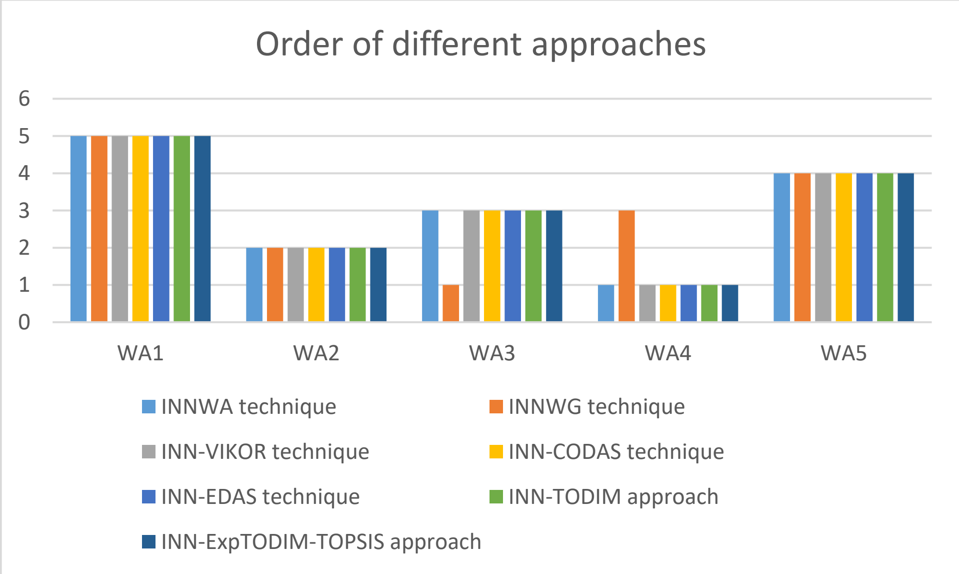

Figure 1. Order of different approaches

From the above analysis, it could be administrated that the seven approaches have the same optimal local-applied undergraduate college and university and worst local-applied undergraduate college and university and the six techniques' order is the same. This verifies INN-ExpTODIM-TOPSIS technique is reasonable.

5. Conclusion

In the era of globalization, English has become a more important language. With the increasing demand for talent in society, the concepts and techniques of teaching have also been reformed. In the CET, it is necessary to cultivate students as applied talents, not only to enable them to master certain theoretical knowledge, but also to have corresponding practical abilities, to promote their comprehensive development and become useful talents in society. Therefore, this article has certain practical significance in studying the quality evaluation system construction of CET. The CET quality evaluation is classical MAGDM. Currently, the ExpTODIM and TOPSIS approaches are utilized to administrate the MAGDM. In the evaluation of CET quality, the utilization of INSs serves as a valuable tool for capturing uncertain data. In this study, we introduce the INN-ExpTODIM-TOPSIS approach, specifically designed to address MAGDM challenges with INSs. To validate the effectiveness of the INN-ExpTODIM-TOPSIS approach, a numerical study focusing on CET quality evaluation is conducted. Moving forward, our future work aims to explore the integration of various techniques, paving the way for the development of scientific decision-making approaches in the field.

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