NSS
Neutrosophic Sets and Systems, Vol. 79, 2025
University of New Mexico

A Hybrid Approach for Educational Development Assessment in Higher Education with Trapezoidal Fuzzy Neutrosophic Analysis: Towards Optimized Decision-Making and Strategic Improvement

Bin Ge*
Wuxi Vocational College of Science and Technology, Wuxi, 214028, Jiangsu, China
*Corresponding author, E-mail: 13771188342@163.com

Abstract: The rapid advancement of technology has significantly driven social development, leading to transformative changes across various sectors of society. As a result, there are increasing demands for higher standards of management in the education sector. Consequently, reforming education management has become an urgent necessity. In China, higher education plays a pivotal role as the primary platform for cultivating and supplying talent to society. With the emergence of new challenges and heightened societal expectations, ensuring high-quality teaching and implementing effective management reforms in higher education have become critical priorities. The evaluation of innovative development models in higher education management can be approached through multiple-attribute decision-making (MADM) techniques. Among the recent advancements in this domain, the MULTIMOORA method and average models have been applied to address MADM problems. To better represent the inherent uncertainty in decision-making processes, trapezoidal fuzzy neutrosophic sets (TFNSs) have emerged as an effective tool. These sets enable a more nuanced expression of uncertain information, making them particularly suitable for evaluating innovative development modes in higher education management. This study proposes a novel decision-making framework: the trapezoidal fuzzy neutrosophic number MULTIMOORA (TFNN-MULTIMOORA) model. Additionally, the average technique is employed to determine attribute weights within the TFNS framework. To validate the effectiveness and applicability of the proposed TFNN-MULTIMOORA technique, a numerical example focusing on the evaluation of innovative development modes in higher education management is presented, along with comparative analyses.

Keywords: multiple-attribute decision-making (MADM); TFNSs; MULTIMOORA model; innovative development modes evaluation

1. Introduction

Education management refers to the process in which educators organize and coordinate educational teams to effectively utilize human, financial, material, and informational resources within the education system. By leveraging various favorable conditions, the aim is to efficiently achieve educational management goals [1-3]. From a macro perspective, education management encompasses a series of activities where the state organizes, coordinates, and controls the broader education system. For universities, it involves the strategic adjustment of internal resources and educational affairs to align all driving factors, ensuring they are positioned appropriately while maximizing their strengths. Currently, China is experiencing a new phase of comprehensive development across multiple sectors [4, 5]. The rapid advancement of information technology has accelerated the optimization and transformation of industries, driving an increasing demand for highly skilled talent from universities. This has significantly increased the complexity of talent cultivation, presenting universities with unprecedented challenges. As a result, it has become imperative for universities to further refine and enhance their education management models to ensure the smooth operation of various institutional functions. Moreover, these models must enable universities to effectively implement management and educational directives. To address these challenges, it is crucial to thoroughly analyze innovative trends and development pathways in higher education management. This analysis must take into account the unique demands of the current era [6]. These demands reflect broader societal progress, and as institutions deeply embedded in and influenced by societal changes, universities are naturally compelled to adapt to new requirements. They must respond proactively by optimizing and innovating their management practices to remain relevant and effective in this dynamic context. In conclusion, the evolving demands of the modern era require universities to rethink and innovate their approaches to education management. By doing so, they can ensure their systems and practices align with societal progress, meeting the growing complexities of talent cultivation while maintaining the effective operation of their institutions [7]. At present, China's society has entered a state of knowledge explosion, and various emerging concepts are constantly emerging. The ideological consciousness of college students is inherently susceptible to interference from complex social environments[8]. Combined with the continuous upgrading of the education level of the general public, the competition for future employment among college students has become increasingly severe. In light with this, universities should not only seek more living space for their own development, but also consider the quality of students' future employment and entrepreneurship. And university education management is a direct factor that affects the quality of education and management in universities[9]. So in order to cater to the new situation and enhance the vitality of

development of universities in the new era, universities must innovate the mechanisms of educational management forms[10, 11]. Only by actively adapting to the development of the times and optimizing themselves, can universities unleash higher quality industry attractiveness and attract more high-quality and high-quality talents to enter the school. If, in the face of new situations, the management mode of higher education still follows the outdated traditional mode, the quality of talent cultivation and development strategies on campus will not be able to adapt to the new form of society, and the competitiveness of the times will be lost. Therefore, from any perspective, in the new social development pattern, the management mode of higher education must innovate its mechanism, which is an inevitable direction and choice to adapt to the times[12-14]. The actual quality of higher education management models can not only represent the external image of universities, but also directly affect the operational quality of internal education, teaching, and management work[15-17]. The management of higher education consists of two parts: management system and management methods. If the management system is not perfect and cannot be set according to the specific situation of teaching and learning on campus, it will lead to significant management gaps or loopholes in education management, making teaching and daily work unable to proceed smoothly[18, 19]. If the management methods used by managers lack strength or fail to pay attention to humanistic care for the managed, it will cause dissatisfaction among the managed and further reduce the stability of the daily operation of universities[20, 21].

1.1 Research gaps

In short, the lack of innovation in the management mode of higher education will make it difficult for managers to control the fundamental stability of education and daily business, and universities will not be able to operate normally[22, 23]. Therefore, from the perspective of self-optimization and quality assurance in universities, the mode of education management should be optimized[24, 25]. Improving management quality is an essential step and a critical measure to ensure the sustainable and secure development of universities. The quality of education management within universities directly influences not only the overall education quality but also the effective management of students and faculty. Therefore, it is essential for universities to fully recognize the pivotal role of education management and prioritize its continuous improvement. Chinese universities are currently navigating a new phase of development characterized by challenges and opportunities in areas such as talent cultivation, education internationalization, advancements in educational technology, and the industrialization of education.

1.2 Motivation

To effectively address these challenges, higher education management must undergo significant reforms. This includes rethinking traditional management concepts,

strengthening the skills and awareness of management teams, and integrating practical considerations to optimize and innovate evaluation and management systems.

To align universities' operations across various dimensions with the evolving demands of the modern era, structural transformations are necessary. These transformations require a concerted effort to enhance the quality and efficiency of university management while simultaneously elevating educational standards. By doing so, universities can better meet the complex, multifaceted requirements of today's rapidly changing environment. Ultimately, this comprehensive approach will enable universities to adapt to new circumstances, foster continuous improvement, and strengthen their overall competitiveness. By prioritizing the optimization of management systems and embracing innovation, universities can ensure their development remains aligned with societal progress while maintaining their critical role in talent cultivation and knowledge advancement.

1.3 Contribution of this study

The innovative development modes evaluation in higher education management could be put forward MADM. Recently, MULTIMOORA [26,27] was utilized to solve MADM. The TFNSs [28] are put forward better technique for expressing uncertain information during the innovative development modes evaluation in higher education management. In this study, the TFNN-MULTIMOORA model with TFNSs. Finally, numerical example for innovative development modes evaluation in higher education management is put forward with different comparisons to proof the TFNN-MULTIMOORA approach.

Thus, the key contributions of TFNN-MULTIMOORA model are summarized: (1) MULTIMOORA model is enhanced under TFNSs; (2) Finally, numerical example for innovative development modes evaluation in higher education management is put forward with different comparisons to verify TFNN-MULTIMOORA technique.

1.4 Organization of this study

The framework of such study is put forward: Sect. 2 lists the TFNNSs. Sect. 3 put forward the MADM technique in light with TFNN-MULTIMOORA model. Sect. 4 put forward the TFNN-MULTIMOORA through numerical study for innovative development modes evaluation in higher education management with some comparisons. Conclusions are dealt with in Sect. 5.

2. Preliminaries

Ye [28] put forward the TFNSs.

Definition 1[28]**.** The TFNSs $b\eta$ is:

$$b\eta = \left\{ \left(\theta, b\phi_{b\eta}(\theta), b\varphi_{b\eta}(\theta), b\gamma_{b\eta}(\theta) \right) \middle| \theta \in \Theta \right\} \tag{1}$$

where $b\phi_{b\eta}(\theta), b\varphi_{b\eta}(\theta), b\gamma_{b\eta}(\theta)$ is truth-membership (TM), indeterminacy-membership (IM) and falsity-membership (FM) which is dealt with trapezoidal fuzzy numbers (TFNs).

$$b\phi_{b\eta}(\theta)=\left(b\phi_{b\eta}^{L}(\theta),b\phi_{b\eta}^{M}(\theta),b\phi_{b\eta}^{U}(\theta),b\phi_{b\eta}^{R}(\theta)\right) \quad (2)$$

$$b\varphi_{b\eta}(\theta)=\left(b\varphi_{b\eta}^{L}(\theta),b\varphi_{b\eta}^{M}(\theta),b\varphi_{b\eta}^{U}(\theta),b\varphi_{b\eta}^{R}(\theta)\right) \quad (3)$$

$$b\gamma_{b\eta}(\theta)=\left(b\gamma_{b\eta}^{L}(\theta),b\gamma_{b\eta}^{M}(\theta),b\gamma_{b\eta}^{U}(\theta),b\gamma_{b\eta}^{R}(\theta)\right) \quad (4)$$

where $0\le b\phi_{b\eta}^{L}(\theta)\le b\phi_{b\eta}^{M}(\theta)\le b\phi_{b\eta}^{U}(\theta)\le b\phi_{b\eta}^{R}(\theta)\le 1$,

$0\le b\varphi_{b\eta}^{L}(\theta)\le b\varphi_{b\eta}^{M}(\theta)\le b\varphi_{b\eta}^{U}(\theta)\le b\varphi_{b\eta}^{R}(\theta)\le 1$,

$0\le b\gamma_{b\eta}^{L}(\theta)\le b\gamma_{b\eta}^{M}(\theta)\le b\gamma_{b\eta}^{U}(\theta)\le b\gamma_{b\eta}^{R}(\theta)\le 1$.

For convenience, $b\eta=\left\{\left(b\phi^{L},b\phi^{M},b\phi^{U},b\phi^{R}\right),\left(b\varphi^{L},b\varphi^{M},b\varphi^{U},b\varphi^{R}\right),\left(b\gamma^{L},b\gamma^{M},b\gamma^{U},b\gamma^{R}\right)\right\}$ is a TFNN which meets condition $0\le b\phi^{R}+b\varphi^{R}+b\gamma^{R}\le 3$.

In order to fuse the TFNNs, Ye [28] dealt with novel operations on the TFNNs $b\eta$, $b\eta_1$ and $b\eta_2$.

Definition 2[28]. Let $b\eta_1=\left\{\left(b\phi_1^{L},b\phi_1^{M},b\phi_1^{U},b\phi_1^{R}\right),\left(b\varphi_1^{L},b\varphi_1^{M},b\varphi_1^{U},b\varphi_1^{R}\right),\left(b\gamma_1^{L},b\gamma_1^{M},b\gamma_1^{U},b\gamma_1^{R}\right)\right\}$,

$b\eta_2=\left\{\left(b\phi_2^{L},b\phi_2^{M},b\phi_2^{U},b\phi_2^{R}\right),\left(b\varphi_2^{L},b\varphi_2^{M},b\varphi_2^{U},b\varphi_2^{R}\right),\left(b\gamma_2^{L},b\gamma_2^{M},b\gamma_2^{U},b\gamma_2^{R}\right)\right\}$ and $b\eta=\left\{\left(b\phi^{L},b\phi^{M},b\phi^{U},b\phi^{R}\right),\left(b\varphi^{L},b\varphi^{M},b\varphi^{U},b\varphi^{R}\right),\left(b\gamma^{L},b\gamma^{M},b\gamma^{U},b\gamma^{R}\right)\right\}$, the novel operations of TFNNs are put forward:

$$(1)\ b\eta_1\oplus b\eta_2=\left\{\begin{array}{l}\left(b\phi_1^{L}+b\phi_2^{L}-b\phi_1^{L}b\phi_2^{L},b\phi_1^{M}+b\phi_2^{M}-b\phi_1^{M}b\phi_2^{M},b\phi_1^{U}+b\phi_2^{U}-b\phi_1^{U}b\phi_2^{U},b\phi_1^{R}+b\phi_2^{R}-b\phi_1^{R}b\phi_2^{R}\right),\\ \left(b\varphi_1^{L}b\varphi_2^{L},b\varphi_1^{M}b\varphi_2^{M},b\varphi_1^{U}b\varphi_2^{U},b\varphi_1^{R}b\varphi_2^{R}\right),\\ \left(b\gamma_1^{L}b\gamma_2^{L},b\gamma_1^{M}b\gamma_2^{M},b\gamma_1^{U}b\gamma_2^{U}\right)\end{array}\right\};$$

$$(2)\ b\eta_1\otimes b\eta_2=\left\{\begin{array}{l}\left(b\phi_1^{L}b\phi_2^{L},b\phi_1^{M}b\phi_2^{M},b\phi_1^{U}b\phi_2^{U},b\phi_1^{R}b\phi_2^{R}\right),\\ \left(b\varphi_1^{L}+b\varphi_2^{L}-b\varphi_1^{L}b\varphi_2^{L},b\varphi_1^{M}+b\varphi_2^{M}-b\varphi_1^{M}b\varphi_2^{M},b\varphi_1^{U}+b\varphi_2^{U}-b\varphi_1^{U}b\varphi_2^{U},b\varphi_1^{R}+b\varphi_2^{R}-b\varphi_1^{R}b\varphi_2^{R}\right),\\ \left(b\gamma_1^{L}+b\gamma_2^{L}-b\gamma_1^{L}b\gamma_2^{L},b\gamma_1^{M}+b\gamma_2^{M}-b\gamma_1^{M}b\gamma_2^{M},b\gamma_1^{U}+b\gamma_2^{U}-b\gamma_1^{U}b\gamma_2^{U},b\gamma_1^{R}+b\gamma_2^{R}-b\gamma_1^{R}b\gamma_2^{R}\right)\end{array}\right\};$$

$$(3)\ \xi\times b\eta=\left\{\begin{array}{l}\left(1-\left(1-b\phi^{L}\right)^{\xi},1-\left(1-b\phi^{M}\right)^{\xi},1-\left(1-b\phi^{U}\right)^{\xi}\right),\\ \left(\left(b\varphi^{L}\right)^{\xi},\left(b\varphi^{M}\right)^{\xi},\left(b\varphi^{U}\right)^{\xi}\right),\\ \left(\left(b\gamma^{L}\right)^{\lambda\xi},\left(b\gamma^{M}\right)^{\xi},\left(b\gamma^{U}\right)^{\xi}\right)\end{array}\right\},\xi>0;$$

$$(4)\ b\eta^{\xi}=\left\{\begin{array}{l}\left(\left(b\phi^{L}\right)^{\xi},\left(b\phi^{M}\right)^{\xi},\left(b\phi^{U}\right)^{\xi},\left(b\phi^{R}\right)^{\xi}\right),\\ \left(1-\left(1-b\varphi^{L}\right)^{\xi},1-\left(1-b\varphi^{M}\right)^{\xi},1-\left(1-b\varphi^{U}\right)^{\xi},1-\left(1-b\varphi^{R}\right)^{\xi}\right),\\ \left(1-\left(1-b\gamma^{L}\right)^{\xi},1-\left(1-b\gamma^{M}\right)^{\xi},1-\left(1-b\gamma^{U}\right)^{\xi},1-\left(1-b\gamma^{R}\right)^{\xi}\right)\end{array}\right\},\xi>0.$$

Then, these operation laws have different properties.

$$(1)b\eta_1\oplus b\eta_2=b\eta_2\oplus b\eta_1, b\eta_1\otimes b\eta_2=b\eta_2\otimes b\eta_1,\left(\left(b\eta_1\right)^{\xi_1}\right)^{\xi_2}=\left(b\eta_1\right)^{\xi_1\xi_2};\quad(5)$$

$$(2)\ \xi\left(b\eta_1\oplus b\eta_2\right)=\xi b\eta_1\oplus\xi b\eta_2,\left(b\eta_1\otimes b\eta_2\right)^{\xi}=\left(b\eta_1\right)^{\xi}\otimes\left(b\eta_2\right)^{\xi};\quad(6)$$

$$(3)\ \xi_1 b\eta_1\oplus\xi_2 b\eta_1=\left(\xi_1+\xi_2\right)b\eta_1,\left(b\eta_1\right)^{\xi_1}\otimes\left(b\eta_1\right)^{\xi_2}=\left(b\eta_1\right)^{(\xi_1+\xi_2)}.\quad(7)$$

Ye [28] put forward the TFNN Euclid distance (TFNNED).

Definition 4[28]. Let $b\eta_1=\left\{\left(b\phi_1^L,b\phi_1^M,b\phi_1^U,b\phi_1^R\right),\left(b\varphi_1^L,b\varphi_1^M,b\varphi_1^U,b\varphi_1^R\right),\left(b\gamma_1^L,b\gamma_1^M,b\gamma_1^U,b\gamma_1^R\right)\right\}$, $b\eta_2=\left\{\left(b\phi_2^L,b\phi_2^M,b\phi_2^U,b\phi_2^R\right),\left(b\varphi_2^L,b\varphi_2^M,b\varphi_2^U,b\varphi_2^R\right),\left(b\gamma_2^L,b\gamma_2^M,b\gamma_2^U,b\gamma_2^R\right)\right\}$, the TFNNED is constructed:

$$TFNNED\left(b\eta_1,b\eta_2\right)=\sqrt{\frac{1}{12}\left(\begin{array}{l}\left|b\phi_1^L-b\phi_2^L\right|^2+\left|b\phi_1^M-b\phi_2^M\right|^2+\left|b\phi_1^U-b\phi_2^U\right|^2+\left|b\phi_1^R-b\phi_2^R\right|^2\\ +\left|b\varphi_1^L-b\varphi_2^L\right|^2+\left|b\varphi_1^M-b\varphi_2^M\right|^2+\left|b\varphi_1^U-b\varphi_2^U\right|^2+\left|b\varphi_1^R-b\varphi_2^R\right|^2\\ +\left|b\gamma_1^L-b\gamma_2^L\right|^2+\left|b\gamma_1^M-b\gamma_2^M\right|^2+\left|b\gamma_1^U-b\gamma_2^U\right|^2+\left|b\gamma_1^R-b\gamma_2^R\right|^2\end{array}\right)}\quad(8)$$

Ye [28] put forward the TFNN score values (TFNNSV) and TFNN accuracy values (TFNNAV) in order to compare two TFNNs.

Definition 5[28]. Let $b\eta=\left\{\left(b\phi^L,b\phi^M,b\phi^U,b\phi^R\right),\left(b\varphi^L,b\varphi^M,b\varphi^U,b\varphi^R\right),\left(b\gamma^L,b\gamma^M,b\gamma^U,b\gamma^R\right)\right\}$, the TFNNSV and TFNNAV are put forward:

$$TFNNSV\left(b\eta\right)=\frac{1}{12}\left[\begin{array}{l}8+\left(b\phi^L+b\phi^M+b\phi^U+b\phi^R\right)-\left(b\varphi^L+b\varphi^M+b\varphi^U+b\varphi^R\right)\\ -\left(b\gamma^L+b\gamma^M+b\gamma^U+b\gamma^R\right)\end{array}\right],$$

$$TFNNSV\left(b\eta\right)\in\left[0,1\right]\quad(9)$$

$$TFNNAV\left(b\eta\right)=\frac{1}{4}\left[\left(b\phi^L+b\phi^M+b\phi^U+b\phi^R\right)-\left(b\gamma^L+b\gamma^M+b\gamma^U+b\gamma^R\right)\right],$$

$$TFNNAV\left(b\eta\right)\in\left[-1,1\right]\quad(10)$$

For TFNNs $x\eta_1$ and $x\eta_2$, then

(1) *if* $TFNNSV\left(b\eta_1\right) \text{p}\ TFNNSV\left(b\eta_2\right)$, *then* $b\eta_1 \text{p}\ b\eta_2$;

(2) *if* $TFNNSV\left(b\eta_1\right) = TFNNSV\left(b\eta_2\right), TFNNAV\left(b\eta_1\right) \text{p}\ TFNNAV\left(b\eta_2\right)$, *then* $b\eta_1 \text{p}\ b\eta_2$;

(3) *if* $TFNNSV\left(b\eta_1\right) = TFNNSV\left(b\eta_2\right), TFNNAV\left(b\eta_1\right) = TFNNAV\left(b\eta_2\right)$, *then* $b\eta_1 = b\eta_2$.

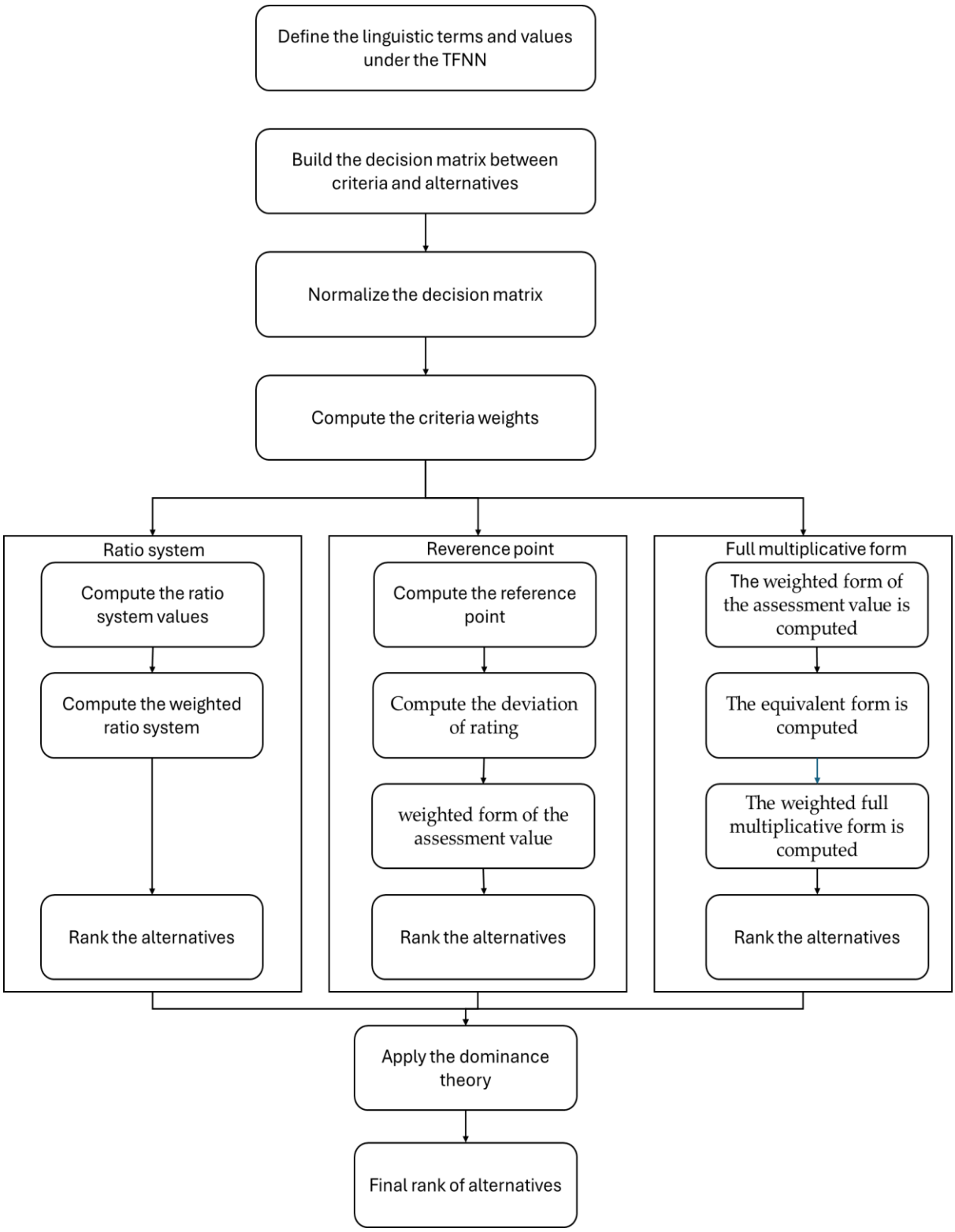

Figure 1. The steps of the TFNN-MULTIMOORA.

3. TFNN-MULTIMOORA approach for MADM

The reference point technique and the ratio system are the two components of the MOORA method, which was first presented by Brauers and Zavadskas. The MOORA approach was expanded by Brauers and Zavadskas to consider the entire multiplicative form. The whole multiplicative form and the MOORA subordinate portions are included in the updated method, which is called MULTIMOORA. Figure 1 shows the steps of the proposed method. The MULTIMOORA method starts with the decision matrix X with a set of criteria and alternatives:

The decision matrix is normalized to obtain the comparable and dimensionless rating. The normalization method is a comparison between the criteria and alternatives. The equation below is used to normalize the decision matrix as:

$$L_{ij} = \frac{x_{ij}}{\left[\sum_{i=1}^{m} x_{ij}^2\right]^{1/2}} \tag{11}$$

The criteria weights are computed using the average method.

$$W = \left[w_j\right]_{1\times n} \tag{12}$$

$$\sum_{j=1}^{n} w_j = 1 \tag{13}$$

3.1 The ratio system

To compute the ratio system the normalized values are added for positive criteria and subtracted from negative criteria as:

$$t_i = \sum_{j=1}^{g} L_{ij} - \sum_{j=g+1}^{n} L_{ij} \tag{14}$$

Where g refers to the number of positive criteria and (n-g) refers to the negative criteria.

The weighted form of the ratio system is computed by using the criteria weights as:

$$t_i^w = \sum_{j=1}^{g} L_{ij} w_j - \sum_{j=g+1}^{n} L_{ij}\, w_j \tag{15}$$

The best alternative in the ratio system can be computed as the highest score in the weighted normalized values.

3.2 The reference point method

This method is started with the maximal criteria reference point. The maximal objective reference point can be computed as:

$$r_j = \begin{cases} \max L_{ij}, j \le g \\ \min L_{ij}, j \le g \end{cases} \tag{15}$$

Compute the deviation of rating from the reference point as:

$$d_i = \max\left|r_j - L_{ij}\right| \tag{16}$$

The weighted form of the assessment value of the reference point method can be computed as:

$$z_i = \max\left|w_j r_j - w_j L_{ij}\right| \tag{17}$$

The best alternative form this approach can be computed based on the minimum value of the assessment values.

3.3 The full multiplicative form

The third part in the MULTIMOORA methodology is a full multiplicative form. The assessment value can be computed as:

$$Q_i = \frac{\prod_{j=1}^{g}(x_{ij})}{\prod_{j=g+1}^{n}(x_{ij})} \quad (18)$$

The equivalent form can be computed as:

$$F_i = \frac{\prod_{j=1}^{g}(L_{ij})}{\prod_{j=g+1}^{n}(L_{ij})} \quad (19)$$

The weighted full multiplicative form can be computed as:

$$S_i = \frac{\prod_{j=1}^{g}(L_{ij})^{w_j}}{\prod_{j=g+1}^{n}(L_{ij})^{w_j}} \quad (20)$$

The best alternative can be computed by the maximum assessment value

3.4 Final rank of the alternatives by the dominance theory

The dominance theory used serval ranks and applied dominance to obtain the final rank of alternatives. The final rank can be computed by the combined all three ranks.

4. Application in decision making problem

This section shows the illustrative example of the case study to compute the criteria weights and rank the alternatives. This section shows the results of the MULTIMOORA method under the trapezoidal fuzzy neutrosophic numbers to deal with the vague and uncertain information in the decision-making process.

4.1 Case Study

Universities are the primary battleground for education, with teaching as their central activity, yet the importance of management cannot be overlooked. University education management involves the organization of educational teams by administrators to ensure the efficient and scientific allocation of teaching resources. This process serves as the backbone for achieving higher education goals. As a driving force for educational development and a guarantee of educational quality, effective management is indispensable to the growth and success of universities. Higher education management exhibits comprehensive, social, and directional characteristics, all of which are critical to supporting talent development. Each era brings its own priorities, and in the current age of rapidly advancing information technology, particularly with the rise of the Internet, colleges and universities worldwide are increasingly emphasizing education management. However, the reform and innovation of college education management face numerous challenges and obstacles. Firstly, the complexity of higher education management stems from its involvement of multiple stakeholders and intricate processes. This often results in lengthy work cycles and lags in management efficiency. Problems arising in the management process are difficult to address promptly, leading to delays and inefficiencies. Secondly, the digital age has empowered individuals with equal rights, granting students—the central participants in education management—greater autonomy and more distinct personalities. This shift makes education management more complex than

ever before. Additionally, the emergence of new technologies has introduced advanced tools for teaching and management, rendering traditional methods increasingly obsolete and necessitating systematic updates and upgrades. Higher education management today faces pressing challenges that demand immediate solutions. This encompasses not only teaching management but also student, faculty, and administrative management. In teaching management, universities must align with the demands of the digital era by leveraging online resources to enrich teaching content and enhance the appeal of education. Upgrading management tools and building digital teaching platforms can significantly improve teaching efficiency. For student management, universities should cater to students' diverse developmental needs, granting them more choices and decision-making power. This approach fosters greater interest in learning and supports a more dynamic and engaging management model. In faculty management, strengthening the teaching workforce is essential. Universities should attract exceptional talent, implement effective teacher assessment mechanisms, and create an environment that maximizes teaching potential, ultimately enhancing teaching quality. With regard to administrative management, universities can adopt practices from the corporate world, analyzing the pros and cons of centralized and decentralized management to build an efficient, streamlined administrative system. As a cornerstone of national talent development, higher education is a driving force for a nation's long-term progress. Therefore, higher education management plays a vital role in maintaining and improving the quality of education. In the face of a rapidly evolving social landscape, it is crucial for higher education management to adapt to the times through comprehensive transformation. This includes upgrading teaching tools and content, tailoring management practices to students' needs, and fostering innovation in management approaches. Ultimately, a fully modernized and innovative university education management system is essential to meet the demands of the present era and ensure the long-term success of higher education institutions. The innovative development modes evaluation in higher education management is MADM. Seven higher education management innovative development modes are assessed through employing ten attributes.

Table 1. The linguistic terms of the TFNN

	Terms	TFNN
A	Very Very Low	((0.10,0.12,0.14,0.15),(0.85,0.87,0.90,0.95),(0.05,0.07,0.10,0.15))
B	Very Low	((0.15,0.17,0.19,0.20),(0.75,0.80,0.83,0.85),(0.15,0.17,0.19,0.20))
C	Low	((0.12,0.12,0.24,0.25),(0.67,0.69,0.73,0.75),(0.20,0.21,0.24,0.25))
D	Medium Low	((0.25,0.27,0.29,0.30),(0.55,0.57,0.63,0.65),(0.25,0.27,0.29,0.30))
E	Medium	((0.50,0.53,0.54,0.55),(0.45,0.47,0.52,0.55),(0.30,0.35,0.37,0.40))
F	Medium High	((0.55,0.57,0.63,0.65),(0.25,0.27,0.29,0.30),(0.25,0.27,0.29,0.30))
G	High	((0.65,0.70,0.73,0.75),(0.20,0.21,0.23,0.25),(0.20,0.21,0.23,0.25))
H	Very High	((0.75,0.80,0.83,0.85),(0.15,0.17,0.19,0.20),(0.15,0.16,0.19,0.20))
I	Very Very High	((0.85,0.89,0.93,0.95),(0.10,0.11,0.14,0.15),(0.05,0.10,0.13,0.15))

4.2 Solving the illustrative example

The aim of this study is to compute the criteria weights and rank the alternatives to select the best one. Three experts are evaluated the criteria and alternatives using the TFNN as shown in Table 1. Then we evaluate the criteria and alternatives as shown in Table 2 by using the TFNN. Then we apply the score function to obtain the crip values. Then we combined these matrices into one matrix.

Table 2. The TFNN information.

D_1	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))
C_2	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))
C_3	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))
C_4	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))
C_5	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))
C_6	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))
C_7	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))
C_8	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))
C_9	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))
C_{10}	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))

D_2	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))
C_2	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))
C_3	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))
C_4	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))
C_5	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))
C_6	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))
C_7	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))
C_8	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))
C_9	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))
C_{10}	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))

D_3	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))
C_2	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))
C_3	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))
C_4	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))
C_5	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))
C_6	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.55,0.57,0.63,0.65),(0.25, 0.27,0.29,0.30),(0.25,0.27,0. 29,0.30))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))
C_7	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))
C_8	((0.75,0.80,0.83,0.85),(0.15, 0.17,0.19,0.20),(0.15,0.16,0. 19,0.20))	((0.50,0.53,0.54,0.55),(0.45, 0.47,0.52,0.55),(0.30,0.35,0. 37,0.40))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))
C_9	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))	((0.65,0.70,0.73,0.75),(0.20, 0.21,0.23,0.25),(0.20,0.21,0. 23,0.25))	((0.25,0.27,0.29,0.30),(0.55, 0.57,0.63,0.65),(0.25,0.27,0. 29,0.30))	((0.12,0.12,0.24,0.25),(0.67, 0.69,0.73,0.75),(0.20,0.21,0. 24,0.25))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.15,0.17,0.19,0.20),(0.75, 0.80,0.83,0.85),(0.15,0.17,0. 19,0.20))	((0.10,0.12,0.14,0.15),(0.85, 0.87,0.90,0.95),(0.05,0.07,0. 10,0.15))

Then we computed the criteria weighs as shown in Table 3.

Table 3. The weights of criteria.

Criteria	Notation	Weight	Rank
C_1	W_1	0.0872	1
C_2	W_2	0.096372	3
C_3	W_3	0.111414	10

C_4	W_4	0.099728	6
C_5	W_5	0.104492	9
C_6	W_6	0.103815	8
C_7	W_7	0.099325	5
C_8	W_8	0.099023	4
C_9	W_9	0.09607	2
C_{10}	W_{10}	0.102562	7

Eq. (11) is used to normalize the decision matrix as shown in Table 4.

Table 4. The normalization matrix

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	0.422902	0.435584	0.401674	0.367214	0.356462	0.329169	0.315936
C_2	0.375273	0.3714	0.313777	0.330483	0.289082	0.27746	0.594142
C_3	0.273911	0.519859	0.321152	0.342336	0.282173	0.437876	0.40377
C_4	0.331223	0.270936	0.500735	0.31491	0.294105	0.382762	0.483713
C_5	0.387415	0.358076	0.38164	0.336591	0.3657	0.422992	0.387415
C_6	0.424724	0.307775	0.397397	0.40805	0.40805	0.358723	0.324449
C_7	0.539694	0.38628	0.297524	0.385564	0.339754	0.334267	0.308499
C_8	0.580357	0.396601	0.366566	0.314301	0.322815	0.297983	0.282374
C_9	0.2797	0.516932	0.48203	0.401977	0.295564	0.308255	0.2797
C_{10}	0.356579	0.305738	0.31402	0.311719	0.355199	0.372453	0.564545

4.2.1 The ratio system

Eq. (14) is used to compute the ratio system values. Then Eq. (15) is used to compute the weight sum of ratio system as shown in Table 5.

Table 5. The weight sum ratio system.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	0.036877	0.037983	0.035026	0.032021	0.031083	0.028703	0.02755
C_2	0.036166	0.035792	0.030239	0.031849	0.027859	0.026739	0.057258
C_3	0.030517	0.05792	0.035781	0.038141	0.031438	0.048786	0.044986
C_4	0.033032	0.02702	0.049937	0.031405	0.02933	0.038172	0.048239
C_5	0.040482	0.037416	0.039878	0.035171	0.038213	0.044199	0.040482
C_6	0.044093	0.031952	0.041256	0.042362	0.042362	0.037241	0.033683
C_7	0.053605	0.038367	0.029552	0.038296	0.033746	0.033201	0.030642
C_8	0.057469	0.039273	0.036299	0.031123	0.031966	0.029507	0.027962
C_9	0.026871	0.049662	0.046309	0.038618	0.028395	0.029614	0.026871
C_{10}	0.036572	0.031357	0.032207	0.031971	0.03643	0.0382	0.057901

4.2.2 The reference point method

Then we compute the reference point. Then we compute the deviation of rating from the reference point. Then we computed the weight for the assessment values as shown in Table 6.

Table 6. The weighted assessment values.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	9.64E-05	0	0.000258	0.00052	0.000602	0.000809	0.00091
C_2	0.002033	0.002069	0.002604	0.002449	0.002833	0.002941	0
C_3	0.003053	0	0.002467	0.002204	0.00295	0.001018	0.001441
C_4	0.001686	0.002285	0	0.001848	0.002055	0.001173	0.000169
C_5	0.000388	0.000709	0.000452	0.000943	0.000626	0	0.000388
C_6	0	0.00126	0.000295	0.00018	0.00018	0.000711	0.001081
C_7	0	0.001514	0.002389	0.001521	0.001973	0.002027	0.002281
C_8	0	0.001802	0.002096	0.002609	0.002525	0.002769	0.002922
C_9	0.00219	0	0.000322	0.001061	0.002043	0.001926	0.00219

C_{10}	0.002188	0.002722	0.002635	0.002659	0.002202	0.002021	0

4.2.3 The full multiplicative form

Then we compute the full multiplicate form as shown in Table 7.

Table 7. The full multiplicative form.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	0.927701	0.930095	0.923545	0.916349	0.913978	0.907651	0.90441
C_2	0.90987	0.90896	0.894311	0.898793	0.887274	0.883772	0.951063
C_3	0.865649	0.929706	0.881131	0.887425	0.86852	0.912098	0.903895
C_4	0.895659	0.877892	0.933346	0.891159	0.885106	0.908671	0.930132
C_5	0.905666	0.898244	0.904245	0.892455	0.900223	0.914018	0.905666
C_6	0.914939	0.884853	0.908644	0.911142	0.911142	0.899037	0.889712
C_7	0.94058	0.909848	0.886559	0.909681	0.898324	0.896872	0.889754
C_8	0.947546	0.912489	0.905401	0.891714	0.894077	0.887018	0.882305
C_9	0.884797	0.938576	0.932294	0.916169	0.889499	0.893099	0.884797
C_{10}	0.899639	0.885556	0.887987	0.887318	0.899281	0.903666	0.943048

4.2.4 Final rank of the alternatives by the dominance theory

Then we applied the dominance theory to obtain the final rank of the alternatives as shown in Table 8.

Table 8. The final rank of alternatives.

Criteria	Ratio system	Reference point	Full multiplication form	Final rank
A_1	7	1	7	7
A_2	5	5	5	5
A_3	4	7	4	4
A_4	2	6	2	2
A_5	1	2	1	1
A_6	3	3	3	3
A_7	6	4	6	6

4.3. Comparative analysis

To solve MCGDM problems in an incomplete, ambiguous, and unpredictable environment, numerous esteemed academics working on intelligent systems, artificial intelligence, and soft computing have created innovative decision-making ideas. Our expanded TFNN-MULTIMOORA approach and other decision-making techniques were compared in this study in order to examine each of their features with regard to application domains, criterion types, calculation operators employed, and fundamental concepts.

Then, TFNN-MULTIMOORA approach is compared TFNN-VIKOR technique [29], , TFNN-CE technique [30], TFNN-GRA model [31] and TFNN-MABAC model [32]. The order is expressed in Table 9.

Table 9. The comparative analysis results.

Criteria	TFNN-MABAC technique	TFNN-GRA model	TFNN-VIKOR technique	TFNN-CE method	Proposed
A_1	7	7	7	7	7
A_2	5	5	4	5	5

A_3	4	4	5	4	4
A_4	2	3	2	2	2
A_5	1	1	1	1	1
A_6	3	2	3	3	3
A_7	6	6	6	6	6

5. Conclusion

To achieve sustainable and stable improvement in the quality of higher education, it is essential to continuously innovate and refine the management modes of higher education. Currently, with the rapid advancement of the economy and technology, China's higher education management faces significant challenges. These challenges include outdated educational goals and content, insufficient emphasis on humanistic care in educational methods, and a lack of scientific rigor in management systems. As the evolving societal and technological landscape presents increasingly complex demands, it is imperative to reshape and improve the management modes of higher education to address these issues effectively. In response to these challenges, higher education management must innovate by aligning its management content with the context of the times. This requires a rethinking of traditional approaches, actively improving the work quality of management teams, and reshaping the evaluation systems within education management. Furthermore, the internal management system of higher education should be rebuilt using scientific thinking as the foundation and supervision as a guiding principle. By addressing these aspects through both internal logic and external oversight, universities can optimize and innovate their management modes to better meet modern requirements. The evaluation of innovative development modes in higher education management can be approached through MADM. This methodology allows for the systematic assessment of diverse factors influencing higher education management. Recently, the MULTIMOORA approach and average models have been utilized to address MADM problems in this context. These methods provide robust tools for analyzing and prioritizing decision-making criteria, particularly when dealing with complex and multi-dimensional issues. However, the uncertainty inherent in higher education management requires advanced techniques to enhance decision-making. To address this, TFNSs have emerged as a more effective framework for handling uncertain data in the evaluation of innovative development modes in higher education management. In this study, a TFNN-MULTIMOORA model is proposed. To validate the effectiveness of the TFNN-MULTIMOORA model, a numerical example is presented, along with comparative analyses to demonstrate the model's advantages over existing methods.

The key advantages of the TFNN-MULTIMOORA approach in addressing innovative development modes evaluation in higher education management are as follows:

- Handling Uncertainty: The TFNN-MULTIMOORA approach effectively incorporates uncertainty into the evaluation process. It not only provides a robust mechanism for

addressing the ambiguity and vagueness inherent in higher education management but also captures the shape similarity degree during the evaluation of innovative development modes. This ensures a more accurate and realistic representation of the decision-making environment.

- The uncertainty information is solved by using the neutrosophic numbers.

In conclusion, the proposed TFNN-MULTIMOORA approach represents a significant advancement in the evaluation of management modes in higher education. By addressing uncertainty, leveraging advanced techniques, and integrating multiple methodologies, this approach provides a robust, efficient, and scientifically sound framework for optimizing higher education management. As universities continue to face complex and evolving challenges, the TFNN-MULTIMOORA method offers a valuable tool for ensuring the continuous improvement and innovation of management practices in higher education.

References

[1] F. Andersen, C.C. Konijnendijk, T.B. Randrup, Higher education on urban forestry in europe: An overview, Forestry, 75 (2002) 501-511.

[2] W. Cheng, H. Jiang, The innovation research of teaching methods on higher education of management discipline, in: 3rd International Conference on Teaching and Computational Science (WTCS 2009), Springer-Verlag Berlin, Shenzhen, PEOPLES R CHINA, 2009, pp. 353-358.

[3] I. Zitter, E. De Bruijn, P.R.J. Simons, T.J. Ten Cate, Adding a design perspective to study learning environments in higher professional education, Higher Education, 61 (2011) 371-386.

[4] M.B. Vieules, J. Oberlé, E. Cormier, Innovative training strategy for higher education: The photonics training platform at university of bordeaux, in: 14th Conference on Education and Training in Optics and Photonics (ETOP), Spie-Int Soc Optical Engineering, Hangzhou, PEOPLES R CHINA, 2017.

[5] S.M. Yakovleva, M.O. Suraeva, A.P. Zhabin, World trends impacting the change of the higher education system in russia in the conditions of global crisis management on the basis of entrepreneurship and innovations, in: Scientific and Practical Conference on Humans as an Object of Study by Modern Science, Springer International Publishing Ag, Nizhny Novgorod, RUSSIA, 2017, pp. 121-128.

[6] J. Chen, Research on innovation and entrepreneurship education of hotel major in higher vocational colleges based on the perspective of integration of production and education, in: International Conference on Education and Educational Research (ICEER), Singapore Management & Sports Science Inst Pte Ltd, Montreal, CANADA, 2019, pp. 145-150.

[7] R. Ferreras-Garcia, J. Sales-Zaguirre, E. Serradell-López, Competences in higher education tourism internships, Education and Training, 62 (2019) 64-80.

[8] M.B. Garcia, O. Roa, N.D. Acosta, Classroom pedagogical projects (cpp) with ict for the development of research proficiency in higher education: A classroom experience, in: International Congress of Innovation and Trends in Engineering (CONIITI), Ieee, Bogota, COLOMBIA, 2019.

[9] E.A. Tokareva, Y.V. Smirnova, L.G. Orchakova, Innovation and communication technologies: Analysis of the effectiveness of their use and implementation in higher education, Education and Information Technologies, 24 (2019) 3219-3234.

[10] R. Bruni, G. Catalano, C. Daraio, M. Gregori, H.F. Moed, Studying the heterogeneity of european higher education institutions, Scientometrics, 125 (2020) 1117-1144.

[11] R. Pérez-delHoyo, H. Mora, P. Martí-Ciriquián, M.L. Pertegal-Felices, R. Mollá-Sirvent, Introducing innovative technologies in higher education: An experience in using geographic information systems for the teaching-learning process, Computer Applications in Engineering Education, 28 (2020) 1110-1127.

[12] M.M. Pinheiro, V. Santos, Stem learning in digital higher education: Have it your way!, in: 4th International Conference on Innovative Technologies and Learning (ICITL), Springer International Publishing Ag, Electr Network, 2021, pp. 567-578.

[13] S. Son-Turan, The hesfs for higher education funding, employment and sustainability, International Journal of Sustainability in Higher Education, 22 (2021) 100-119.

[14] D.M. Kong, B.H. Zhang, J. Zhang, Higher education and corporate innovation, Journal of Corporate Finance, 72 (2022) 31.

[15] J. Membrillo-Hernández, W.J. Cuervo-Bejarano, P. Vázquez-Villegas, Digital global classroom, a collaborative online international learning (coil) approach: An innovative pedagogical strategy for sustainable competency development and dissemination of sdgs in engineering higher education, in: 25th International Conference on Interactive Collaborative Learning (ICL) / 51st IGIP International Conference on Engineering Pedagogy, Springer International Publishing Ag, Vienna, AUSTRIA, 2022, pp. 25-35.

[16] M.H.H. Roslan, S. Hamid, M.T. Ijab, F.D. Yusop, A.A. Norman, Social entrepreneurship in higher education: Challenges and opportunities, Asia Pacific Journal of Education, 42 (2022) 588-604.

[17] C.Y. Sun, J.A. Liu, L. Razmerita, Y.R. Xu, J. Qi, Higher education to support sustainable development: The influence of information literacy and online learning process on chinese postgraduates' innovation performance, Sustainability, 14 (2022) 16.

[18] C.L. Wang, P.Y. Zheng, F.R. Zhang, Y.F. Qian, Y.Y. Zhang, Y.L. Zou, Exploring quality evaluation of innovation and entrepreneurship education in higher institutions using

deep learning approach and fuzzy fault tree analysis, Frontiers in Psychology, 12 (2022) 16.

[19] F.F. Zhao, G.Q. Zhang, Z.L. Wang, X.Y. Hao, Construction of higher education management data analysis model based on association rules, Scientific Programming, 2022 (2022) 12.

[20] A. Ayoub, S.M. Almahamid, L.F. Al Salah, Innovative work behavior scale: Development and validation of psychometric properties in higher education in the gcc countries, European Journal of Innovation Management, 26 (2023) 119-133.

[21] E. Bootsma, L. Jansen, G. Kiekens, W. Voorpoels, P. Mortier, S. Proost, I. vande Poel, K. Jacobs, K. Demyttenaere, J. Alonso, R.C. Kessler, P. Cuijpers, R.P. Auerbach, R. Bruffaerts, Mood disorders in higher education in flanders during the 2nd and 3rd covid-19 wave: Prevalence and help-seeking: Findings from the flemish college surveys (flecs), Journal of Psychiatric Research, 159 (2023) 33-41.

[22] D. Galgotia, N. Lakshmi, Development of iot-based methodology for the execution of knowledge management using artificial intelligence in higher education system, Soft Computing, (2023) 10.

[23] M. Podgórska, I. Zdonek, Interdisciplinary collaboration in higher education towards sustainable development, Sustainable Development, (2023) 19.

[24] Y. Qu, S. Chen, S.G. Cao, Examination in accordance with aptitude: Selection and optimization of curriculum assessment methods in higher education adapted to the teacher-student game behaviors, Sustainability, 15 (2023) 26.

[25] B.X. Yan, J. Lyu, How does an innovative decision-making scheme affect the high-quality economic development driven by green finance and higher education?, Environmental Science and Pollution Research, 30 (2023) 115721-115733.

[26] A. Hafezalkotob, A. Hafezalkotob, and M. K. Sayadi, "Extension of MULTIMOORA method with interval numbers: an application in materials selection," *Appl. Math. Model.*, vol. 40, no. 2, pp. 1372–1386, 2016.

[27] A. Baležentis, T. Baležentis, and R. Valkauskas, "Evaluating situation of Lithuania in the European Union: structural indicators and MULTIMOORA method," *Technol. Econ. Dev. Econ.*, vol. 16, no. 4, pp. 578–602, 2010

[28] A. Petrovas, R. Bausys, E.K. Zavadskas, F. Smarandache, Generation of creative game scene patterns by the neutrosophic genetic cocoso method, Studies in Informatics and Control, 31 (2022) 5-11.

[29] J. Ye, Trapezoidal neutrosophic set and its application to multiple attribute decision-making, Neural Computing and Applications, 26 (2015) 1157-1166.

[29] J. Wang, G.W. Wei, M. Lu, An extended vikor method for multiple criteria group

decision making with triangular fuzzy neutrosophic numbers, Symmetry-Basel, 10 (2018) 15.

[30] L. Li, Cross-entropy method for efficiency evaluation of integrated development of agriculture and tourism to promote rural revitalization under the triangular fuzzy neutrosophic sets, Journal of Intelligent & Fuzzy Systems, 44 (2023) 6151-6161.

[31] B. Xie, Modified gra methodology for madm under triangular fuzzy neutrosophic sets and applications to blended teaching effect evaluation of college english courses, Soft Computing, (2023) https://doi.org/10.1007/s00500-00023-08891-00506.

[32] I. Irvanizam, N.N. Zi, R. Zuhra, A. Amrusi, H. Sofyan, An extended mabac method based on triangular fuzzy neutrosophic numbers for multiple-criteria group decision making problems, Axioms, 9 (2020) 18.

Received: Sep 21, 2024. Accepted: Dec 15, 2024