Research Article

Cheng Yang* and Jing Liu

Research on teaching quality evaluation of higher vocational architecture majors based on enterprise platform with spherical fuzzy MAGDM

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Abstract: Teaching quality evaluation is a process of evaluating the teaching quality of architectural majors. It can not only evaluate the teaching level of teachers, but also evaluate the learning effectiveness of students. Therefore, this study designs a teaching quality evaluation system for architecture majors based on fuzzy environment, in order to provide direction guidance for effectively evaluating the teaching quality of architecture majors by using this research. The teaching quality evaluation of higher vocational architecture majors based on enterprise platform is a multiple-attribute group decision-making (MAGDM). The spherical fuzzy sets (SFSs) provide more free space for decision makers to portray uncertain information during the teaching quality evaluation of higher vocational architecture majors based on enterprise platform. Therefore, this study expands the partitioned Maclaurin symmetric mean operator and induced ordered weighted average operator to SFSs based on the power average technique and construct induced spherical fuzzy power partitioned MSM (I-SFPPMSM) technique. Subsequently, a novel MAGDM method is put forward based on I-SFPPMSM technique and spherical fuzzy number weighted geometric technique under SFSs. Finally, a numerical example for teaching quality evaluation of higher vocational architecture majors based on enterprise platform is employed to verify the put forward method, and comparative analysis with some existing techniques to testy the validity and superiority of the I-SFPPMSM technique.

Keywords: multiple-attribute group decision-making, spherical fuzzy sets, I-SFPPMSM operator, teaching quality evaluation

1 Introduction

As China's higher vocational education enters the stage of connotation development, many studies have conducted beneficial exploration on ways to improve the quality of talent cultivation in terms of specialty setting, curriculum system, and talent cultivation mode reform, in combination with the needs of regional industrial development for talents. After the launch of the demonstrative higher vocational college construction project, how to construct a practical teaching system based on work process with vocational education characteristics is the most concerned content in the field of vocational education and teaching reform. From the perspective of the employment positions of students majoring in civil engineering in higher vocational colleges, after graduation, students mainly engage in the most grass-roots technical and management work in the production line, serving as on-site construction workers, documenters, safety officers, materials officers,

*** Corresponding author: Cheng Yang,** School of Architecture and Art, Ningbo Polytechnic, Ningbo, 315000, Zhejiang, China, e-mail: 13967886559@163.com
Jing Liu: Zhejiang Nuclear Power Construction Special Technology Co., Ltd, Ningbo 315000, Zhejiang, China

budget officers, etc. [1–3]. Therefore, civil engineering professionals in higher vocational colleges are defined as high-quality construction technology and management talents in the construction line. High-quality construction technology and management talents are compound and innovative talents, who should develop comprehensively in terms of "knowledge, ability, and quality," possess both professional theoretical knowledge of architecture and be adept at transforming engineering drawings into engineering entities [4,5]. The practical teaching system is a training system for cultivating students' practical abilities, emphasizing the systematic and coordinated nature of basic courses, specialized courses, experiments, practical training, and internships. Centering on the needs of enterprises in the construction industry, in accordance with the law of talent growth, it clarifies the corresponding requirements for professional knowledge, professional skills, and professional qualities of each professional position, and aims to meet professional needs and adapt to the needs of socio-economic development and technological progress, deconstruct the original discipline system, adopt typical "student-centered" work tasks and processes, and reconstruct a practical teaching system based on work processes [6,7]. Higher education has shifted from cultivating "specialized, deep, and top-notch" talents with the characteristics of "discipline based" in the past to cultivating composite talents integrating "knowledge, ability, and quality." Higher vocational education should carefully understand the functional positioning and internal relationship of teaching, scientific research, and social services in colleges and universities, and implement the educational concept of "knowledge, ability, and quality" in a trinity. It should scientifically and systematically design and construct two systems, namely, "theoretical teaching" and "practical teaching," to cultivate high-quality construction technology and management talents by using "school-enterprise cooperation, and work–study integration" [6–9]. In order to achieve its objectives, higher vocational education in architecture not only needs to establish two curriculum systems that support theoretical teaching and practical teaching, but also needs to flexibly and crossly apply the two systems. Numerous research results have shown that "the common problems existing in higher vocational graduates are weak practical skills, slow job adaptation, and insufficient job retention. The main reason is that the basic knowledge is not firmly grasped." However, basic knowledge and abilities are difficult to make up for in the work of enterprise positions. Especially, in construction enterprises, due to the production of single and large pieces of products, large volume, complex processes, and rapid technology and material updates, students are objectively required to have good engineering quality and continuous learning ability [10,11]. How to handle the relationship between "knowledge, ability, and quality" and promote the sustainable development of students requires strengthening the systematic design of the "two systems" of theoretical and practical teaching in the curriculum system, so as to integrate them and comprehensively cultivate students' abilities. The theoretical curriculum system is a training system for cultivating students' basic public knowledge and professional knowledge for sustainable development, enabling them to possess high knowledge, high ability, and high quality. Public and professional basic knowledge should be integrated into system design. Basic courses have a "tool + quality" function. By strengthening basic courses such as foreign languages, mathematics, computers, architectural drawings, CAD, and architectural mechanics, students are trained in foreign language reading, logical thinking, information processing, and engineering qualities, laying a solid foundation for the cultivation of subsequent professional abilities [12,13]. For example, advanced mathematics solves such issues as basic knowledge of advanced mathematics, engineering calculations, logical reasoning, rigorous thinking, and innovative awareness; Foreign language courses (including professional foreign languages) can not only improve students' humanistic literacy, but also cultivate their literature reading ability; the course of architectural mechanics can not only systematically cultivate students' mechanical knowledge required in subsequent professional courses and future work, but also train students' engineering thinking abilities. The practical curriculum system is a training system for cultivating students' practical abilities, enabling them to possess high abilities, high quality, and high knowledge. Emphasis should be placed on the systematization and coordination of specialized basic courses; specialized technical courses; and experiments, experiments, practical training, and internships [14,15]. The development of practical courses requires cooperation between schools and enterprises, and the corresponding requirements for professional basic knowledge, professional technical knowledge, professional skills, and quality of each professional position should be clarified in accordance with the needs of industry and enterprises and the law of talent growth. On this basis, by using action-oriented and project-driven teaching methods, typical work tasks and typical cases are integrated into professional teaching to systematically train students' professional, methodological, and social abilities. In the specific implementation process, school and enterprise jointly develop curriculum evaluation standards, form a new mechanism for school and enterprise cooperation to evaluate the quality of talent cultivation, and achieve sustainable improvement by using the ISO9000 quality management system [16,17].

Decision-making is a conscious and selective behavior of humans, which is generally used to achieve certain goals [18–23]. Multi-attribute decision-making (MADM) refers to sorting or selecting the optimal alternative solution from a limited number of options under multiple attributes [24–29]. Therefore, on the basis of MADM, decision-makers change from individual to group, and multiple people participate in decision analysis and sort or select alternative solutions, which is multiple-attribute group decision-making (MAGDM) [30–36]. In order to portray the uncertain information, Zadeh [37] put forward fuzzy sets (FSs). Atanassov [38] put forward intuitionistic FSs. Yager [39] put forward the Pythagorean FSs. Cuong [40] put forward the picture fuzzy sets. Mahmood et al. [41] put forward the spherical fuzzy sets (SFSs). Thus, SFSs were useful for portraying the fuzziness of things [42–44]. The teaching quality evaluation of higher vocational architecture majors based on enterprise platform is the MAGDM. The SFSs [45] are useful tool to portray uncertain information during the teaching quality evaluation of higher vocational architecture majors based on enterprise platform. Unfortunately, we were unable to find a valuable work for partitioned Maclaurin symmetric mean (PMSM) operator [46] based on induced ordered weighted average (IOWA) [47] and power average (PA) [48] under SFSs [45] during existing research literatures. Therefore, it is valuable to investigate the PMSM technique with SFSs based on IOWA operator and PA technique. Therefore, this study extended PMSM technique [46] and IOWA technique [47] to SFSs based on the PA [48] and construct induced spherical fuzzy power PMSM (I-SFPPMSM) operator. Subsequently, a novel MAGDM technique is put forward based on I-SFPPMSM technique and spherical fuzzy number weighted geometric (SFNWG) technique under SFSs. Finally, a decision example for teaching quality evaluation of higher vocational architecture majors based on enterprise platform is employed to verify the put forward technique, and comparative techniques with some existing techniques to testy the validity and superiority of the I-SFPPMSM technique.

To do this, the framework of this work is produced: Section 2 reviews the SFSs. In Section 3, the I-SFPPMSM technique is put forward. Section 4 constructs the SF-MAGDM based on I-SFPPMSM and SFNWG technique. Section 5 employs an example for teaching quality evaluation of higher vocational architecture majors based on enterprise platform. Finally, we end this article in Section 5.

2 Preliminaries

The SFSs are put forward [45].

Definition 1. [45] The existing SFSs WW in Θ are put forward as follows:

$$\mathrm{WW} = \{(\theta, \mathrm{WT}(\theta), \mathrm{WI}(\theta), \mathrm{WF}(\theta))|\theta \in \Theta\}, \tag{1}$$

where $\mathrm{WT}(\theta), \mathrm{WI}(\theta),$ and $\mathrm{WF}(\theta)$ is truth-membership, indeterminacy-membership and falsity-membership, $\mathrm{WT}(\theta), \mathrm{WI}(\theta),$ and $\mathrm{WF}(\theta) \in [0,1]$, and meets $0 \le \mathrm{WT}^2(\theta) + \mathrm{WI}^2(\theta) + \mathrm{WF}^2(\theta) \le 1$. The spherical fuzzy number (SFN) could be put forward as WW = (WT,WI,WF), where $\mathrm{WT}, \mathrm{WI}, \mathrm{WF} \in [0,1]$, and $0 \le \mathrm{WT}^2 + \mathrm{WI}^2 + \mathrm{WF}^2 \le 1$.

Definition 2. [45] Let $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$, the score value (SV) is put forward as:

$$\mathrm{SV}(\mathrm{WA}) = (\mathrm{WT}_A - \mathrm{WI}_A)^2 - (\mathrm{WF}_A - \mathrm{WI}_A)^2, \quad \mathrm{SV}(\mathrm{WA}) \in [0,1]. \tag{2}$$

Definition 3. [45] Let $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$, the accuracy value (AV) is put forward as:

$$\mathrm{AV}(\mathrm{WA}) = (\mathrm{WT}_A)^2 + (\mathrm{WT}_A)^2 + (\mathrm{WF}_A)^2, \quad \mathrm{AV}(\mathrm{WA}) \in [0,1]. \tag{3}$$

Peng et al. [49] put forward the decision order for SFSs.

Definition 4. [45] Let $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$ and $\mathrm{WB} = (\mathrm{WT}_B, \mathrm{WI}_B, \mathrm{WF}_B)$ be SFNs, let $SV(\mathrm{WA}) = (\mathrm{WT}_A - \mathrm{WI}_A)^2 - (\mathrm{WF}_A - \mathrm{WI}_A)^2$ and $SV(\mathrm{WB}) = (\mathrm{WT}_B - \mathrm{WI}_B)^2 - (\mathrm{WF}_B - \mathrm{WI}_B)^2$, and let $AV(\mathrm{WA}) = (\mathrm{WT}_A)^2 + (\mathrm{WT}_A)^2 + (\mathrm{WF}_A)^2$ and $AV(\mathrm{WB}) = (\mathrm{WT}_B)^2 + (\mathrm{WT}_B)^2 + (\mathrm{WF}_B)^2$, respectively, then if $SV(\mathrm{WA}) < SV(\mathrm{WB})$, then $\mathrm{WA} < \mathrm{WB}$; if $SV(\mathrm{WA}) = SV(\mathrm{WB})$, then (1)if $AV(\mathrm{WA}) = AV(\mathrm{WB})$, then $\mathrm{WA} = \mathrm{WB}$; (2) if $AV(\mathrm{WA}) < AV(\mathrm{WB})$, then $\mathrm{WA} < \mathrm{WB}$.

Definition 5. [45,50] Let $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$ and $\mathrm{WB} = (\mathrm{WT}_B, \mathrm{WI}_B, \mathrm{WF}_B)$ be SFNs, and some mathematical operations are put forward as:

(1) $\mathrm{WA} \oplus \mathrm{WB} = \left(\sqrt{\mathrm{WT}_A^2 + \mathrm{WT}_B^2 - \mathrm{WT}_A^2\mathrm{WT}_B^2}, \mathrm{WI}_A\mathrm{WI}_B, \mathrm{WF}_A\mathrm{WF}_B\right)$;

(2) $\mathrm{WA} \otimes \mathrm{WB} = \left(\mathrm{WT}_A\mathrm{WT}_B, \sqrt{\mathrm{WI}_A^2 + \mathrm{WI}_B^2 - \mathrm{WI}_A^2\mathrm{WI}_B^2}, \sqrt{\mathrm{WF}_A^2 + \mathrm{WF}_B^2 - \mathrm{WF}_A^2\mathrm{WF}_B^2}\right)$;

(3) $\lambda \times \mathrm{WA} = \left(\sqrt{1 - (1 - \mathrm{WT}_A^2)^\lambda}, (\mathrm{WI}_A)^\lambda, (\mathrm{WF}_A)^\lambda\right), \lambda > 0$;

(4) $(\mathrm{WA})^\lambda = \left((\mathrm{WT}_A)^\lambda, \sqrt{1 - (1 - \mathrm{WI}_A^2)^\lambda}, \sqrt{1 - (1 - \mathrm{WF}_A^2)^\lambda}\right), \lambda > 0$.

Definition 6. [51,52] Let $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$ and $\mathrm{WB} = (\mathrm{WT}_B, \mathrm{WI}_B, \mathrm{WF}_B)$, and then the SFN Hamming distance (SFNHD) between $\mathrm{WA} = (\mathrm{WT}_A, \mathrm{WI}_A, \mathrm{WF}_A)$ and $\mathrm{WB} = (\mathrm{WT}_B, \mathrm{WI}_B, \mathrm{WF}_B)$ is put forward as:

$$\mathrm{SFNHD}(\mathrm{WA}, \mathrm{WB}) = \frac{1}{2}\left(|\mathrm{WT}_A^2 - \mathrm{WT}_B^2| + |\mathrm{WI}_A^2 - \mathrm{WI}_B^2| + |\mathrm{WF}_A^2 - \mathrm{WF}_B^2|\right). \tag{4}$$

The SFNWG technique [45] is put forward.

Definition 7. [45] Let $\mathrm{WA}_j = (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ be SFNs, and the SVNNWG operator is put forward as:

$$\mathrm{SFNWG}_{ww}(\mathrm{WA}_1, \mathrm{WA}_2, \cdots, \mathrm{WA}_n) = \bigotimes_{j=1}^{n} (\mathrm{WA}_j)^{ww_j} = \left(\begin{array}{l} \prod_{j=1}^{n} (\mathrm{WT}_j)^{ww_j}, \\ \sqrt{\prod_{j=1}^{n} (1 - \mathrm{WF}_j^2)^{ww_j} - \prod_{j=1}^{n} (1 - \mathrm{WF}_j^2 - \mathrm{WI}_j^2)^{ww_j}}, \\ \sqrt{1 - \prod_{j=1}^{n} (1 - \mathrm{WF}_j^2)^{ww_j}} \end{array}\right) \tag{5}$$

where $ww = (ww_1, ww_2, \ldots, ww_n)^T$ be the weight values of $\mathrm{WA}_j (j = 1, 2, \ldots, n)$ and $ww_j > 0$, $\sum_{j=1}^{n} ww_j = 1$.

Definition 8. [46] Let $\mathrm{WX} = \{wx_1, wx_2, \cdots, wx_q\}$ be non-negative, which are fully divided into we different information partitions $\mathrm{WY}_1, \mathrm{WY}_2, \cdots, \mathrm{WY}_{we}$ with $WY_\eta \cap WY_x = \varnothing$ and $\cup_{wb=1}^{we} \mathrm{WY}_{wb} = \mathrm{WA}$, then PMSM is put forward as:

$$\mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(wx_1, wx_2, \cdots, wx_q) = \frac{1}{we}\left(\sum_{wb=1}^{we}\left(\frac{1}{C_{|\mathrm{WY}_{wb}|}^{g_{wb}}}\left(\sum_{1 \le \eta_1 < \cdots < \eta_{g_{wb}} \le |WY_{wb}|} \prod_{x=1}^{g_{wb}} wx_{\eta_x}\right)\right)^{\frac{1}{g_{wb}}}\right), \tag{6}$$

where $|\mathrm{WY}_{wb}|$ is the information cardinality of $\mathrm{WY}_{wb} (wb = 1, 2, \cdots, we)$ and $\sum_{wb=1}^{we} |\mathrm{WY}_{wb}| = q$, g_{wb} is the parameter in the partition WY_{wb} and $g_{wb} = 1, 2, \cdots, |\mathrm{WY}_{wb}|$. $(\eta_1, \eta_2, \ldots, \eta_{g_{wb}})$ traverses all the g_{wb}-tuple information combination of $(1, 2, \ldots, |\mathrm{WY}_{wb}|)$, and $C_{|\mathrm{WY}_{wb}|}^{g_{wb}}$ portrays the binomial coefficient meeting $C_{|\mathrm{WY}_{wb}|}^{g_{wb}} = \frac{|\mathrm{WY}_{wb}|!}{g_{wb}!(|\mathrm{WY}_{wb}| - g_{wb})!}$.

The PMSM operator has three properties:

(1) $\mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(0, 0, \cdots, 0) = 0$, $\mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(wx_1, wx_2, \cdots, wx_q) = wx$.

(2) $\mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(wx_1, wx_2, \cdots, wx_q) \le \mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(wx_1', wx_2', \cdots, wx_q')$, if $lx_\eta \le lx_\eta'$ for all η.

(3) $\min_\eta\{wx_\eta\} \le \mathrm{PMSM}^{(g_1, g_2, \cdots g_{we})}(wx_1, wx_2, \cdots, wx_q) \le \max_\eta\{wx_\eta\}$.

3 I-SFPPMSM operator

The SFPPMSM technique are put forward [53].

Definition 9. [53] Let $WA_j = (WT_j, WI_j, WF_j)$ be SFNs, which are fully divided into we different information partitions $WY_1, WY_2, \cdots, WY_{we}$ with $WY_\eta \cap WY_x = \varnothing$ and $\cup_{wb=1}^{we} WY_{wb} = WA$, then SFWPPMSM operator is put forward as:

$$
\begin{aligned}
&SFPPMSM^{(g_1,g_2,\cdots g_{we})}(WA_1, WA_2, \cdots, WA_q) \\
&= \frac{1}{we}\left(\bigoplus_{wb=1}^{we}\left(\frac{1}{C_{|WA_{lb}|}^{g_{wb}}}\left(\bigoplus_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WY_{wb}|}\left(\bigotimes_{x=1}^{g_{wb}}\left(\frac{(1+TT(WA_{\eta_x}))}{\sum_{x=1}^{g_{lb}}(1+TT(WA_{\eta_x}))}WA_{\eta_x}\right)\right)\right)^{\frac{1}{g_{wb}}}\right)\right) \\
&= \left(\sqrt{1-\left(\prod_{wb=1}^{we}\left(1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WY_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(1-WT_{\eta_x}^2)^{(1+TT(WA_{\eta_x}))/\sum_{x=1}^{g_{wb}}(1+TT(WA_{\eta_x}))}\right)\right)\right)^{\frac{1}{C_{|WA_{lb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}\right)\right)^{\frac{1}{we}}}\right), \\
&\times\left(\prod_{wb=1}^{we}\sqrt{1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WY_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(WI_{\eta_x})^{2(1+TT(WA_{\eta_x}))/\sum_{x=1}^{g_{wb}}(1+TT(WA_{\eta_x}))}\right)\right)\right)^{\frac{1}{C_{|WA_{lb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}}\right)^{\frac{1}{we}}, \\
&\times\left(\prod_{wb=1}^{we}\sqrt{1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WY_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(WF_{\eta_x})^{2(1+TT(WA_{\eta_x}))/\sum_{x=1}^{g_{wb}}(1+TT(WA_{\eta_x}))}\right)\right)\right)^{\frac{1}{C_{|WA_{lb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}}\right)^{\frac{1}{we}},
\end{aligned} \tag{7}
$$

where $|WY_{wb}|$ is the information cardinality of $WY_{wb}(wb = 1, 2, \cdots, we)$ and $\sum_{wb=1}^{we}|WY_{wb}| = q$, g_{wb} is the parameter in the partition WY_{wb} and $g_{wb} = 1, 2, \cdots, |WY_{wb}|$. $(\eta_1, \eta_2, \ldots, \eta_{g_{wb}})$ traverses all the g_{wb}-tuple information combination of $(1, 2, \ldots, |WY_{wb}|)$, and $C_{||WY_{wb}||}^{g_{wb}}$ portrays the binomial coefficient meeting $C_{|WY_{wb}|}^{g_{wb}} = \frac{|WY_{wb}|!}{g_{wb}!(|WY_{wb}|-g_{wb})!}$, where $TT(WA_a) = \sum_{j=1, a\neq j}^{m} Sup(WA_a, WA_j)$, $Sup(WA_a, WA_j)$ is the decision support for WA_a from WA_j, with decision conditions: (1) $Sup(WA_a, WA_b) \in [0, 1]$; (2) $Sup(WA_b, WA_a) = Sup(WA_a, WA_b)$; (3) $Sup(WA_a, WA_b) \ge Sup(WA_s, WA_t)$, if $SFNHD(WA_a, WA_b) \ge SFNHD(WA_s, WA_t)$, where SFNHD is a Hamming distance measure.

Moreover, SFPPMSM technique has three properties [53]:

Property 1. (Idempotence) Let $WA_j = (WT_j, WI_j, WF_j)$ be the SFNs with parameter $(g_1, g_2, \ldots, g_{we})$, if $LA_\eta = LA = (LT, LI, LF)$ for all η, we have:

$$SFPPMSM^{(g_1,g_2,\cdots g_{we})}(WA_1, WA_2, \cdots, WA_q) = WA. \tag{8}$$

Property 2. (Monotonicity) Let $WA_j = (WT_j, WI_j, WF_j)$ and $WA'_j = (WT'_j, WI'_j, WF'_j)$ be the SFNs with parameter $(g_1, g_2, \ldots, g_{we})$, if $WT_\eta \ge WT'_\eta$, $WI_\eta \le WI'_\eta$, $WF_\eta \le WF'_\eta$ for all η, we have:

$$\begin{aligned}&\mathrm{SFPPMSM}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}_1,\mathrm{WA}_2,\cdots,\mathrm{WA}_q)\\ \geq\;&\mathrm{SFPPMSM}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}'_1,\mathrm{WA}'_2,\cdots,\mathrm{WA}'_q).\end{aligned} \tag{9}$$

Property 3. (Boundness) Let $\mathrm{WA}_j = (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ be the SFNs with parameter $(g_1, g_2,..., g_{we})$, if $\mathrm{WA}^+ = (\max_\eta \mathrm{WT}_\eta, \min_\eta \mathrm{WI}_\eta, \min_\eta \mathrm{WF}_\eta)$ and $\mathrm{WA}^- = (\min_\eta \mathrm{WT}_\eta, \max_\eta \mathrm{WI}_\eta, \max_\eta \mathrm{WF}_\eta)$, we have:

$$\mathrm{WA}^- \leq \mathrm{SFPPMSM}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}_1,\mathrm{WA}_2,\cdots,\mathrm{WA}_q) \leq \mathrm{WA}^+. \tag{10}$$

Yager and Filev [47] put forward induced OWA (IOWA) technique based on OWA [54].

Definition 10. [47] An IOWA technique: $R^a \to R$ is put forward as:

$$\mathrm{IOWA}(\langle w\theta_1, wk_1\rangle, \langle w\theta_2, wk_2\rangle, \cdots, \langle w\theta_n, wk_n\rangle) = \sum_{j=1}^{n} ww_j wk_{\sigma(j)}. \tag{11}$$

$wk_{\sigma(j)}$ is the wk_j of OWA pair $\langle w\theta_j, wk_j\rangle$ having the j-th largest $w\theta_j (w\theta_j \in [0,1])$, $w\theta_j$ in $\langle w\theta_j, wk_j\rangle$ is the order-inducing values, and wk_j is the variable, and $ww = (ww_1, ww_2, \cdots, ww_n)$ is the ordered weight values.

Then, the induced spherical fuzzy power PMSM (I-SFPPMSM) operator is put forward based on IOWA operator [47] and SFPPMSM operator [53].

Definition 11. Let $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ be a set of 2-tuples and SFNs, which could be divided into we different information partitions $\mathrm{WY}_1, \mathrm{WY}_2, \cdots, \mathrm{WY}_{we}$ with $WY_\eta \cap WY_x = \varnothing$ and $\cup_{wb=1}^{we} WY_{wb} = WA$, $\mathrm{WA}_{\sigma(j)}$ is WA_j of I-SFPPMSM pair $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ having the j-th largest $w\theta_j (w\theta_j \in N)$,and $w\theta_j$ in $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ is put forward as order-inducing information and $(\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ are the SFNs, then I-SFPPMSM is put forward as:

$$\begin{aligned}&\text{I-SFPPMSM}_{ww}^{(g_1,g_2,\cdots g_{we})}(\{w\theta_1,\mathrm{WA}_1\},\{W\theta_2,\mathrm{WA}_2\},\cdots,\{W\theta_q,\mathrm{WA}_q\})\\ &= \frac{1}{we}\left(\bigoplus_{wb=1}^{we}\left(\frac{1}{C_{|\mathrm{WA}_{wb}|}^{g_{wb}}}\left(\bigoplus_{1\leq\eta_1<\cdots<\eta_{g_{wb}}\leq|WA_{wb}|}\bigotimes_{x=1}^{g_{wb}}\left(\frac{(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}{\sum_{x=1}^{g_b}(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}\mathrm{WA}_{\eta_{\sigma(x)}}\right)\right)\right)^{\frac{1}{g_{wb}}}\right),\end{aligned} \tag{12}$$

where $|\mathrm{WY}_{wb}|$ is the information cardinality of $\mathrm{WY}_{wb} (wb = 1, 2, \cdots, we)$ and $\sum_{wb=1}^{we} |\mathrm{WY}_{wb}| = q$, g_{wb} is the parameter in the partition WY_{wb} and $g_{wb} = 1, 2, \cdots, |\mathrm{WY}_{wb}|$. $(\eta_1, \eta_2, ..., \eta_{g_{wb}})$ traverses all the g_{wb}-tuple information combination of $(1, 2, ..., |\mathrm{WY}_{wb}|)$, and $C_{|\mathrm{WY}_{wb}|}^{g_{wb}}$ portrays the binomial coefficient meeting $C_{|\mathrm{WY}_{wb}|}^{g_{wb}} = \frac{|\mathrm{WY}_{wb}|!}{g_{wb}!(|\mathrm{WY}_{wb}| - g_{wb})!}$, where $\mathrm{TT}(\mathrm{WA}_a) = \sum_{j=1, a\neq j}^{m} \mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_j)$, $\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_j)$ is the decision support for WA_a from WA_j, with decision conditions: (1) $\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_b) \in [0, 1]$; (2) $\mathrm{Sup}(\mathrm{WA}_b, \mathrm{WA}_a) = \mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_b)$; and (3) $\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_b) \geq \mathrm{Sup}(\mathrm{WA}_s, \mathrm{WA}_t)$, if $\mathrm{SFNHD}(\mathrm{WA}_a, \mathrm{WA}_b) \geq \mathrm{SFNHD}(\mathrm{WA}_s, \mathrm{WA}_t)$, where SFNHD is a Hamming distance measure.

Theorem 1. *Let* $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ *be a set of* 2*-tuples and SFNs, which could be divided into we different information partitions* $\mathrm{WY}_1, \mathrm{WY}_2, \cdots, \mathrm{WY}_{we}$ *with* $WY_\eta \cap WY_x = \varnothing$ *and* $\cup_{wb=1}^{we} WY_{wb} = WA$, $WA_{\sigma(j)}$ *is* WA_j *of I-SFPPMSM pair* $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ *having the j-th largest* $w\theta_j (w\theta_j \in N)$, *and* $w\theta_j$ *in* $\{w\theta_j, \mathrm{WA}_j\} = \{w\theta_j, (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)\}$ *is put forward as order-inducing information and* $(\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ *are the SFNs, then I-SFPPMSM is put forward as*:

$$
\begin{aligned}
&\text{I-SFPPMSM}_{WW}^{(g_1,g_2,\cdots g_{we})}(\{w\theta_1,\mathrm{WA}_1\},\{W\theta_2,\mathrm{WA}_2\},\cdots,\{W\theta_q,\mathrm{WA}_q\})\\
&=\frac{1}{we}\left(\bigoplus_{wb=1}^{we}\left(\frac{1}{C_{|\mathrm{WA}_{wb}|}^{g_{wb}}}\left(\bigoplus_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|\mathrm{WA}_{wb}|}\ \bigotimes_{x=1}^{g_{wb}}\left(\frac{(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}{\sum_{x=1}^{g_b}(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}\mathrm{WA}_{\eta_{\sigma(x)}}\right)\right)\right)^{\frac{1}{g_{wb}}}\right)\\
&=\left(\sqrt{1-\left(\prod_{wb=1}^{we}\left(1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WA_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(1-\mathrm{LT}_{\eta_{\sigma(x)}}^2)^{\frac{(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}{\sum_{x=1}^{g_{wb}}((1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}})))}}\right)\right)\right)^{\frac{1}{C_{|\mathrm{WA}_{wb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}\right)\right)^{\frac{1}{we}}}\right.,\\
&\times\left(\prod_{wb=1}^{we}\sqrt{1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|WA_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(\mathrm{LI}_{\eta_{\sigma(x)}})^{2\frac{(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}{\sum_{x=1}^{g_{wb}}((1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}})))}}\right)\right)\right)^{\frac{1}{C_{|\mathrm{WA}_{wb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}}\right)^{\frac{1}{we}},\\
&\times\left.\left(\prod_{wb=1}^{we}\sqrt{1-\left(1-\left(\prod_{1\le\eta_1<\cdots<\eta_{g_{wb}}\le|\mathrm{WA}_{wb}|}\left(1-\prod_{x=1}^{g_{wb}}\left(1-(\mathrm{LF}_{\eta_{\sigma(x)}})^{2\frac{(1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}}))}{\sum_{x=1}^{g_{wb}}((1+\mathrm{TT}(\mathrm{WA}_{\eta_{\sigma(x)}})))}}\right)\right)\right)^{\frac{1}{C_{|\mathrm{WA}_{wb}|}^{g_{wb}}}}\right)^{\frac{1}{g_{wb}}}}\right)^{\frac{1}{we}}\right),
\end{aligned}
\tag{13}
$$

where $|\mathrm{WY}_{wb}|$ is the information cardinality of $\mathrm{WY}_{wb}(wb = 1, 2,\cdots, we)$ and $\sum_{wb=1}^{we}|\mathrm{WY}_{wb}| = q$, g_{wb} is the parameter in the partition WY_{wb} and $g_{wb} = 1, 2,\cdots,|\mathrm{WY}_{wb}|$. $(\eta_1, \eta_2,..., \eta_{g_{wb}})$ traverses all the g_{wb}-tuple information combination of $(1, 2,...,|WY_{wb}|)$, and $C_{|WY_{wb}|}^{g_{wb}}$ portrays the binomial coefficient meeting $C_{|\mathrm{WY}_{wb}|}^{g_{wb}} = \frac{|\mathrm{WY}_{wb}|!}{g_{wb}!(|\mathrm{WY}_{wb}|-g_{wb})!}$, where $\mathrm{TT}(\mathrm{WA}_a) = \sum_{j=1, a\ne j}^{m}\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_j)$, $\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_j)$ is the decision support for WA_a from WA_j, with decision conditions: (1) $\mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_b) \in [0, 1]$; (2) $\mathrm{Sup}(\mathrm{WA}_b, \mathrm{WA}_a) = \mathrm{Sup}(\mathrm{WA}_a, \mathrm{WA}_b)$; (3) $\mathrm{Sup}(WA_a, WA_b) \ge \mathrm{Sup}(WA_s, WA_t)$, if $\mathrm{SFNHD}(\mathrm{WA}_a, \mathrm{WA}_b) \ge \mathrm{SFNHD}(\mathrm{WA}_s, \mathrm{WA}_t)$, where SFNHD is a Hamming distance measure.

Moreover, I-SFPPMSM technique has three properties:

Property 4. (Idempotence) Let $\mathrm{WA}_j = (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ be the SFNs with parameter $(g_1, g_2,..., g_{we})$, if $\mathrm{LA}_\eta = \mathrm{LA} = (\mathrm{LT}, \mathrm{LI}, \mathrm{LF})$ for all η, we have:

$$\text{I-SFPPMSM}_{WW}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}_1, \mathrm{WA}_2,\cdots, \mathrm{WA}_q) = \mathrm{WA}. \tag{14}$$

Property 5. (Monotonicity) Let $\mathrm{WA}_j = (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ and $\mathrm{WA}'_j = (\mathrm{WT}'_j, \mathrm{WI}'_j, \mathrm{WF}'_j)$ be the SFNs with parameter $(g_1, g_2,..., g_{we})$, if $\mathrm{WT}_\eta \ge \mathrm{WT}'_\eta$, $\mathrm{WI}_\eta \le \mathrm{WI}'_\eta$, $\mathrm{WF}_\eta \le \mathrm{WF}'_\eta$ for all η, we have:

$$
\begin{aligned}
&\text{I-SFPPMSM}_{WW}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}_1, \mathrm{WA}_2, \cdots, \mathrm{WA}_q)\\
\ge\ &\text{I-SFPPMSM}_{WW}^{(g_1,g_2,\cdots g_{we})}(\mathrm{WA}'_1, \mathrm{WA}'_2, \cdots,\mathrm{WA}'_q).
\end{aligned}
\tag{15}
$$

Property 6. (Boundness) Let $\mathrm{WA}_j = (\mathrm{WT}_j, \mathrm{WI}_j, \mathrm{WF}_j)$ be SFNs with parameter $(g_1, g_2,..., g_{we})$, if $\mathrm{WA}^+ = (\max_\eta \mathrm{WT}_\eta, \min_\eta \mathrm{WI}_\eta, \min_\eta \mathrm{WF}_\eta)$ and $\mathrm{WA}^- = (\min_\eta \mathrm{WT}_\eta, \max_\eta \mathrm{WI}_\eta, \max_\eta \mathrm{WF}_\eta)$, we have:

$$\mathrm{WA}^{-} \le \text{I-SFPPMSM}_{ww}^{(g_1, g_2, \cdots g_{we})}(\mathrm{WA}_1, \mathrm{WA}_2, \cdots, \mathrm{WA}_q) \le \mathrm{WA}^{+}. \tag{16}$$

4 Model for MAGDM based on I-SFPPMSM technique with SFSs

Then, the I-SFPPMSM technique is put forward to manage the MAGDM. Let $\mathrm{WA} = \{\mathrm{WA}_1, \mathrm{WA}_2, \ldots, \mathrm{WA}_m\}$ be alternatives. Let $WG = \{WG_1, WG_2, \ldots, WG_n\}$ be attributes. Assume $\mathrm{WD} = \{\mathrm{WD}_1, \mathrm{WD}_2, \ldots, \mathrm{WD}_l\}$ be decision makers with weight values of $\omega\omega = \{\omega\omega_1, \omega\omega_2, \ldots, \omega\omega_l\}$, where $\omega\omega_k \in [0, 1]$, $\sum_{k=1}^{l} \omega\omega_k = 1$. And $\mathrm{WD}^{(k)} = (\mathrm{WD}_{ij}^{(k)})_{m\times n} = (\mathrm{WT}_{ij}^{(k)}, \mathrm{WI}_{ij}^{(k)}, \mathrm{WF}_{ij}^{(k)})_{m\times n}$ is the SFN matrix, Subsequently, the put forward decision steps are supplied.

Step 1. Mange the SFN-matrix $WD^{(k)} = (WD_{ij}^{(k)})_{m\times n} = (WT_{ij}^{(k)}, WI_{ij}^{(k)}, WF_{ij}^{(k)})_{m\times n}$ and derive the SFNs matrix $WD = (WD_{ij})_{m\times n}$ by employing SFNWG technique.

$$\mathrm{WD}^{(k)} = [\mathrm{WD}_{ij}^{(k)}]_{m\times n} = \begin{bmatrix} \mathrm{WD}_{11}^{(k)} & \mathrm{WD}_{12}^{(k)} & \ldots & \mathrm{WD}_{1n}^{(k)} \\ \mathrm{WD}_{21}^{(k)} & \mathrm{WD}_{22}^{(k)} & \ldots & \mathrm{WD}_{2n}^{(k)} \\ \vdots & \vdots & \vdots & \vdots \\ \mathrm{WD}_{m1}^{(k)} & \mathrm{WD}_{m2}^{(k)} & \ldots & \mathrm{WD}_{mn}^{(k)} \end{bmatrix}, \tag{17}$$

$$\mathrm{WD} = [\mathrm{WD}_{ij}]_{m\times n} = \begin{bmatrix} \mathrm{WD}_{11} & \mathrm{WD}_{12} & \ldots & \mathrm{WD}_{1n} \\ \mathrm{WD}_{21} & \mathrm{WD}_{22} & \ldots & \mathrm{WD}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \mathrm{WD}_{m1} & \mathrm{WD}_{m2} & \ldots & \mathrm{WD}_{mn} \end{bmatrix}, \tag{18}$$

$$\begin{aligned} \mathrm{WD}_{ij} &= (\mathrm{WT}_{ij}, \mathrm{WI}_{ij}, \mathrm{WF}_{ij}) \\ &= \begin{pmatrix} \prod_{k=1}^{l} (\mathrm{WT}_{ij}^{k})^{\omega\omega_k}, \\ \sqrt{\prod_{k=1}^{l} (1 - (\mathrm{WF}_{ij}^{k})^2)^{\omega\omega_k} - \prod_{k=1}^{l} (1 - (\mathrm{WF}_{ij}^{k})^2 - (\mathrm{WI}_{ij}^{k})^2)^{\omega\omega_k}}, \\ \sqrt{1 - \prod_{j=1}^{n} (1 - (\mathrm{WF}_{ij}^{k})^2)^{\omega\omega_k}} \end{pmatrix} \end{aligned} \tag{19}$$

Step 2. Normalize the $\mathrm{WD} = (\mathrm{WD}_{ij})_{m\times n}$ to $\mathrm{NWD} = [\mathrm{NWD}_{ij}]_{m\times n}$.

$$\begin{aligned} \mathrm{NWD}_{ij} &= (\mathrm{NWT}_{ij}, \mathrm{NWI}_{ij}, \mathrm{NWF}_{ij}) \\ &= \begin{cases} (\mathrm{WT}_{ij}, \mathrm{WI}_{ij}, \mathrm{WF}_{ij}), & \mathrm{WG}_j \text{ is a benefit criterion} \\ (\mathrm{WF}_{ij}, \mathrm{WI}_{ij}, \mathrm{WT}_{ij}), & \mathrm{WG}_j \text{ is a cost criterion.} \end{cases} \end{aligned} \tag{20}$$

Step 3. Employ the $\mathrm{NWD} = [\mathrm{NWD}_{ij}]_{m\times n} = (\mathrm{NWT}_{ij}, \mathrm{NWI}_{ij}, \mathrm{NWF}_{ij})_{m\times n}$ and I-SFPPMSM:

$$\begin{aligned} \mathrm{NWD}_i &= (\mathrm{NWT}_i, \mathrm{NWI}_i, \mathrm{NWF}_i) \\ &= \text{I-SFPPMSM}^{(g_1, g_2, \cdots g_{we})} \begin{pmatrix} \{wu_{i1}, (\mathrm{NWT}_{i1}, \mathrm{NWI}_{i1}, \mathrm{NWF}_{i1})\}, \\ \{wu_{i2}, (\mathrm{NWT}_{i2}, \mathrm{NWI}_{i2}, \mathrm{NWF}_{i2})\}, \cdots, \\ \{wu_{in}, (\mathrm{NWT}_{in}, \mathrm{NWI}_{in}, \mathrm{NWF}_{in})\} \end{pmatrix} \end{aligned} \tag{21}$$

to obtain the overall values $\mathrm{NWD}_i = (\mathrm{NWT}_i, \mathrm{NWI}_i, \mathrm{NWF}_i)$.

Step 4. Construct the $\mathrm{SV}(\mathrm{NWD}_i)$ and $\mathrm{AV}(\mathrm{NWD}_i)$ of $\mathrm{WA}_i (i = 1, 2, \cdots, m)$.

Step 5. Rank the decision choices $\mathrm{WA}_i (i = 1, 2, \cdots, m)$ and put forward the optimal one by employing the $\mathrm{SV}(\mathrm{NWD}_i)$ and $\mathrm{AV}(\mathrm{NWD}_i)$.

Step 6. End.

5 Decision example and comparative analysis

5.1 Decision example

Currently, with the development of education, different fields such as science, architecture, and engineering require the reinforcement of teaching content to cultivate talents in various fields with more effective teaching methods and provide guarantee for the development of related fields [55–57]. For colleges and universities, teaching quality is an important guarantee of the effectiveness of school education, and the effectiveness of teaching quality evaluation is directly related to the learning effectiveness of students in related majors [58–62]. Teaching quality can not only reflect the teaching strength of teachers in schools, but also enhance the reputation of colleges and universities [63–65]. It is an effective means to judge the teaching quality of schools. Teaching quality evaluation is an important indicator of teaching feedback, which can comprehensively evaluate the factors that affect teaching effectiveness and can also more concretely evaluate teachers' teaching level [66–68]. With the attitude of "correcting if there is something wrong, encouraging if there is something wrong," we can provide guidance and suggestions to teachers. The teaching quality evaluation system is a common use of teaching evaluation, by using which students can anonymously leave comments on teachers' teaching methods, effectively improving the teaching and learning relationship between teachers and students [69–72]. However, the existing teaching quality evaluation system has a relatively simple content, and teachers and students cannot effectively interact, affecting teaching quality. The off-campus training base mainly combines the content embodied in the training to achieve zero distance contact with technical posts, consolidate students' theoretical knowledge, exercise their vocational skills, and comprehensively improve their abilities in all aspects [9,73–75]. The construction of off-school training bases is conducive to the improvement and innovation of school talent cultivation programs and teaching models driven by the demand for real job employment and enterprise talent introduction. The main job categories of the construction project management specialty are builders, constructors, surveyors, quality inspectors, safety officers, documenters, budget officers, etc. The main reason for choosing to rely on construction enterprises as off-school training bases is that construction enterprises can provide real scenes of the production process of construction products and can provide first-hand technical data, personnel, materials, and equipment as teaching resources for practical training. Schools and teachers enter the forefront of enterprise and engineering management, adjusting talent training programs, curriculum systems, and teaching methods according to the needs of the enterprise. Therefore, using the project department of construction enterprises under construction as an off-school training base can play an irreplaceable role. The teaching quality evaluation of higher vocational architecture majors based on enterprise platform is a MAGDM. Then, a decision example for teaching quality evaluation of higher vocational architecture majors based on enterprise platform is put forward by using I-SFPPMSM technique. In order to construct the most higher vocational college, the decision department invite three experts $\mathrm{WD} = (\mathrm{WD}_1, \mathrm{WD}_2, \mathrm{WD}_3)$ to evaluate the five higher vocational colleges $\mathrm{WA}_i (i = 1, 2, 3, 4, 5)$ by using four attributes: WG_1 is the teaching resource, WG_2 is the teaching content, WG_3 is the student dissatisfaction, and WG_4 is the peer expert teacher evaluation. Assume that five attributes are divided into two parts: $\mathrm{WW}_1 = \{\mathrm{WG}_1, \mathrm{WG}_2\}$ and $\mathrm{WW}_2 = \{\mathrm{WG}_3, \mathrm{WG}_4\}$, Furthermore, $\omega\omega = (0.35, 0.30, 0.35)^T$ is experts' weight values. The decision information from $\mathrm{WD} = (\mathrm{WD}_1, \mathrm{WD}_2, \mathrm{WD}_3)$ by using employing linguistic scale (Table 1) is given in Tables 2–4. The I-SFPPMSM technique is employed to manage the teaching quality evaluation of higher vocational architecture majors based on enterprise platform.

Step 1. Construct the group SFN-matrix $\mathrm{WD}^{(k)} = (\mathrm{WD}_{ij}^{(k)})_{5\times 4}$ $(k = 1, 2, 3)$ (Tables 2–4). The SFN matrix is put forward by using SFNWG. The results are given in Table 5.

Step 2. Normalize the $WD = [WD_{ij}]_{5\times 4}$ to $NWD = [NWD_{ij}]_{5\times 4}$ (see Table 6).

Step 3. Invited assessed experts employ induced information to portray the decision attitude for these decision alternatives. The assessed results are shown in Table 7.

Step 4. The I-SFPPMSM technique is employed to obtain the overall information $\mathrm{NWD}_i = (\mathrm{NWT}_i, \mathrm{NWI}_i, \mathrm{NWF}_i)(i = 1, 2, 3, 4, 5)$ (Table 8). Suppose $g_1 = g_2 = 2$.

Step 5. Calculate the $\mathrm{SV}(\mathrm{NWD}_i)(i = 1, 2, \cdots, 5)$.

Table 1: Linguistic terms and SFNs [45]

Linguistic terms	SFNs
Exceedingly terrible-WET	(0.9, 0.1, 0.1)
Very terrible-WVT	(0.7, 0.3, 0.3)
Terrible-WT	(0.6, 0.4, 0.4)
Medium-WM	(0.5, 0.5, 0.5)
Well-WW	(0.4, 0.4, 0.6)
Very Well-WVW	(0.3, 0.3, 0.7)
Exceedingly well-WEW	(0.1, 0.1, 0.9)

Table 2: SFN information by WD_1

	WG_1	WG_2	WG_3	WG_4
WA_1	WW	WET	WVW	WM
WA_2	WT	WW	WW	WM
WA_3	WM	WW	WT	WVT
WA_4	WW	WM	WVW	WT
WA_5	WW	WVT	WM	WW

Table 3: SFN information by LD_2

	WG_1	WG_2	WG_3	WG_4
WA_1	WT	WVW	WW	WM
WA_2	WW	WW	WM	WT
WA_3	WT	WM	WW	WW
WA_4	WM	WET	WT	WVW
WA_5	WM	WT	WW	WVT

$$\mathrm{SV}(\mathrm{NWD}_1) = 0.0351, \mathrm{SV}(\mathrm{NWD}_2) = 0.3149, \mathrm{SV}(\mathrm{NWD}_3) = -0.0176$$
$$\mathrm{SV}(\mathrm{NWD}_4) = 0.1209, \mathrm{SV}(\mathrm{NWD}_5) = 0.0273.$$

Step 6. In line with $\mathrm{SV}(\mathrm{NWD}_i)$ $(i = 1, 2, \cdots, 5)$, the order is produced: $\mathrm{WA}_2 > \mathrm{WA}_4 > \mathrm{WA}_1 > \mathrm{WA}_5 > \mathrm{WA}_3$, and thus, the optimal higher vocational college is WA_2.

5.2 Comparative analysis

Then, the I-SFPPMSM technique is fully compared with defined existing techniques with SFSs to verify the I-SFPPMSM technique. The results are given in Table 9.

Table 4: SFN information by LD_3

	WG_1	WG_2	WG_3	WG_4
WA_1	WW	WM	WT	WW
WA_2	WT	WW	WW	WT
WA_3	WM	WM	WW	WT
WA_4	WM	WW	WW	WT
WA_5	WW	WT	WT	WM

Table 5: Overall SFN information

	WG_1	WG_2
WA_1	(0.45, 0.21, 0.43)	(0.39, 0.32, 0.45)
WA_2	(0.46, 0.29, 0.37)	(0.49, 0.27, 0.37)
WA_3	(0.49, 0.31, 0.33)	(0.45, 0.28, 0.29)
WA_4	(0.51, 0.26, 0.37)	(0.39, 0.26, 0.52)
WA_5	(0.39, 0.28, 0.47)	(0.46, 0.38, 0.46)
	WG_3	WG_4
WA_1	(0.39, 0.52, 0.45)	(0.38, 0.31, 0.52)
WA_2	(0.29, 0.27, 0.46)	(0.37, 0.35, 0.48)
WA_3	(0.59, 0.38, 0.37)	(0.43, 0.37, 0.39)
WA_4	(0.35, 0.52, 0.37)	(0.36, 0.45, 0.42)
WA_5	(0.46, 0.38, 0.42)	(0.27, 0.29, 0.46)

Table 6: Normalized SFNs

	WG_1	WG_2
WA_1	(0.45, 0.21, 0.43)	(0.39, 0.32, 0.45)
WA_2	(0.46, 0.29, 0.37)	(0.49, 0.27, 0.37)
WA_3	(0.49, 0.31, 0.33)	(0.45, 0.28, 0.29)
WA_4	(0.51, 0.26, 0.37)	(0.39, 0.26, 0.52)
WA_5	(0.39, 0.28, 0.47)	(0.46, 0.38, 0.46)
	WG_3	WG_4
WA_1	(0.39, 0.52, 0.45)	(0.38, 0.31, 0.52)
WA_2	(0.29, 0.27, 0.46)	(0.37, 0.35, 0.48)
WA_3	(0.59, 0.38, 0.37)	(0.43, 0.37, 0.39)
WA_4	(0.35, 0.52, 0.37)	(0.36, 0.45, 0.42)
WA_5	(0.46, 0.38, 0.42)	(0.27, 0.29, 0.46)

Table 7: Inducing variables

	WG_1	WG_2	WG_3	WG_4
WA_1	29	23	26	21
WA_2	23	21	20	17
WA_3	19	28	27	30
WA_4	27	20	25	21
WA_5	28	21	31	32

Table 8: Overall values

WA_1	(0.51, 0.31, 0.38)
WA_2	(0.69, 0.12, 0.22)
WA_3	(0.39, 0.19, 0.43)
WA_4	(0.58, 0.23, 0.19)
WA_5	(0.37, 0.20, 0.16)

Table 9: Order of different techniques

Techniques	Order
SFNWA technique [76]	$WA_2 > WA_4 > WA_1 > WA_5 > WA_3$
SFNWG technique [76]	$WA_2 > WA_4 > WA_5 > WA_1 > WA_3$
SF-SWARA-CODAS technique [77]	$WA_2 > WA_4 > WA_1 > WA_5 > WA_3$
SF-MEREC-CoCoSo technique [78]	$WA_2 > WA_4 > WA_1 > WA_5 > WA_3$
SF-CPT-TODIM technique [79]	$WA_2 > WA_4 > WA_1 > WA_5 > WA_3$
I-SFPPMSM technique	$WA_2 > WA_4 > WA_1 > WA_5 > WA_3$

It is obvious by using Table 9 that the decision order the I-SFPPMSM technique is completely same with SFNWA technique, spherical fuzzy SWARA-CODAS (SF-SWARA-CODAS) technique, spherical fuzzy MEREC-CoCoSo (SF-MEREC-CoCoSo) technique, and spherical fuzzy CPT-TODIM (SF-CPT-TODIM technique, whereas the decision selection of optimal higher vocational colleges and worst higher vocational colleges of these techniques is consistent. The detailed analysis verifies the effectiveness of the I-SFPPMSM technique.

6 Conclusions

The foundation for stable training conditions in off-campus training bases for construction is weak, and long-term mechanisms should not be formed. Construction products have the characteristics of one-time use, and there is also one-time use in the construction production process. The construction site of a construction project is not fixed, the environment is complex, and there are many potential safety hazards. These particularities greatly increase the difficulty of constructing off-school training bases for construction enterprises. Some off-school training bases for construction have "ceased" to function in a sense due to changes in enterprises or the completion of projects. Relying on the construction unit's off-school training base for construction projects, by using the practice and research of actual construction projects, it has been proven that it can be implemented and achieved good benefits under the premise of perfect systems and measures. However, due to the particularity of construction products and industries, building a sustainable and effective off-school training base still requires innovation in multiple ways and measures. For example, try to reform information-based teaching, adopt a construction virtual simulation model, and jointly create a digital electronic construction site with enterprises. In vocational colleges, the construction of simulation training bases is an important path to provide students with a better practical learning platform. Another example is the introduction of third-party talent training or consulting units, similar to service outsourcing, where specialized personnel are assigned to coordinate the needs of the school and the enterprise, ensuring the interests of students, appropriately avoiding school risks, and meeting the needs of the enterprise. This requires more teaching or management personnel to continue exploring, practicing, and researching. The teaching quality evaluation of higher vocational architecture majors based on enterprise platform is a MAGDM. Therefore, this study extended PMSM technique and IOWA technique to SFSs based on PA and construct the I-SFPPMSM technique. Subsequently, a novel MAGDM technique is put forward based on I-SFPPMSM technique and SFNWG technique under SFSs. Finally, a decision example for teaching quality evaluation of higher vocational architecture majors based on enterprise platform is employed to verify the put forward technique, and comparative techniques with some existing techniques to testy the validity and superiority of the I-SFPPMSM technique. Future research could expand the I-SFPPMSM techniques designed in this study along with psychological factors [80–82] under SFSs.

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