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INTEGRATING THE 2-TUPLE MODEL AND FUZZY ANALYTICAL HIERARCHY METHOD TO SOLVE HIGHER EDUCATION STUDENT SELECTION PROBLEMS

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Abstract. *The issue of student selection in higher education is significant for each school with regard to whether it can recruit excellent students. Most student selection methods use arithmetic averages or an analytical hierarchy process (AHP) to sort scores for selected student. However, the arithmetic average method cannot manage qualitative and quantitative data simultaneously. Moreover, qualitative data scores are often fuzzy or are linguistic representations of student ability, increasing the difficulty of selecting students for higher education, and cannot be solved by arithmetic average or AHP method. To resolve these issues, this paper integrates a 2-tuple fuzzy linguistic representation model and the fuzzy analytical hierarchy process (FAHP) method in selecting students for higher education. In the numerical verification, a numerical example of selecting appropriate freshmen is adopted. The proposed method is compared with the arithmetic average, AHP, and FAHP methods.*

Keywords: Analytic hierarchy process, Fuzzy analytic hierarchy process, 2-tuple fuzzy linguistic representation model, Higher education student selection

1. **Introduction.** Selecting students is a crucial task for higher education schools, directly influencing their prestige and competitiveness. Student selection problems are multicriteria decision-making problems. Traditionally, student selection models use an arithmetic average method to sort scores for selected students. However, the data for student selection are qualitative and quantitative, increasing the difficulty of selecting students for higher education, and they cannot be resolved by arithmetic average method. In 1980, Saaty [12] introduced the analytic hierarchy process (AHP) method to deal with complex decision-making problems. AHP is an effective tool that can manage qualitative and quantitative data simultaneously. Many studies have examined the use of AHP methods [1,15-17].

The arithmetic average and AHP methods require that the data comprise precise values. However, the score is often fuzzy or becomes a linguistic representation, based on the commentator's subjective judgments, in selecting students for higher education. The fuzzy analytical hierarchy process (FAHP) is as an extension of the AHP method. It was a very useful method for addressing multicriteria decision-making problems in fuzzy environments. A great deal of works in the literature [5,7,8,10] have been carried out using FAHP methods. Another shortcoming of the arithmetic average and AHP methods is that they lose valuable information that is provided by the commentator. In 2000, Herrera and Martinez [6] proposed the 2-tuple fuzzy linguistic representation model to handle linguistic and numerical information in decision-making, computing it with words without loss of information. Research on the 2-tuple fuzzy linguistic representation model and its applications are progressing rapidly, for example, Wang [14] proposed 2-tuple linguistic hybrid arithmetic aggregation operators and application to multi-attribute group decision making of personnel selection. Chang [2] combined 2-tuple and the soft set-based ranking technique to rank the risk of failures. This method is useful when conducting process failure mode and effects analysis with incomplete information. Liu et al. [11] combined 2-tuple and the linguistic technique for order preference by similarity to ideal solution (TOPSIS) approach for robot evaluation and selection with uncertain and incomplete information.

To resolve these shortcomings, this study proposes a novel technique, integrating the 2-tuple model and FAHP method to solve higher education student selection problems. The rest of this article is organized as follows. Section 2 briefly reviews the literature. A novel approach that integrates the 2-tuple fuzzy linguistic representation model and FAHP method is proposed in Section 3. A numerical example of the higher education student selection is adopted, and the arithmetic average, AHP, and FAHP methods are compared in Section 4. The final section makes conclusions.

2. Related Works.

2.1. Arithmetic average method. The arithmetic average method is a statistical indicator that represents the central tendency of data. This method is most commonly used in multicriteria decision-making problems. It is the sum of a collection of numbers, divided by the number of items. The computation is simple and widely used in higher education student selection problems. However, it is strongly influenced by outliers.

2.2. AHP and FAHP methods. In 1980, Saaty [12] introduced the AHP method to address multicriteria decision-making problems. This method uses a pairwise comparison matrix to calculate the relative importance of attributes, based on an expert's subjective judgment. The FAHP method is an extension of the AHP and is more appropriate and effective than traditional AHP in an uncertain pairwise comparison environment [9]. The FAHP method is explained as follows [3,4].

Step 1: Set up a hierarchy system, including the goal, criteria, subcriteria, and a set of alternatives.

Step 2: Construct the fuzzy pairwise comparison matrix with triangular fuzzy numbers. By using triangular fuzzy numbers, the fuzzy judgment matrix $\tilde{A}$ is constructed as follows:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & 1 & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \tag{1}$$

where $\tilde{a}_{ij} = (L_{ij}, M_{ij}, R_{ij})$ is the fuzzy comparison value of criterion i to criterion j.

Step 3. Calculate the eigenvalues and eigenvectors. In this step, Saaty [12] proposed 5 normalization operators to calculate the eigenvalues: the eigenvector, average of normalized columns, normalization of the row average, normalization of the inverse column sum, and normalization of the geometric mean of the rows.

Step 4. Perform consistency test. The result of the consistency test is decided by consistency index (CI) and consistency ratio (CR) values. If $CR < 0.1$, consistency is achieved. A random index table is shown in Table 1.

$$\text{C.I.} = \frac{\lambda_{\max} - n}{n - 1} \tag{2}$$

$$\text{C.R.} = \frac{\text{C.I.}}{\text{R.I.}} \tag{3}$$

where n is the dimension of the pairwise matrix and $\lambda_{\max}$ represents the maximum eigenvalue of the matrix.

Step 5. Calculate the overall priority of the decision alternatives.

Table 1. Random index table [12]

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	N/A	N/A	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

2.3. **2-tuple fuzzy linguistic representation model.** When addressing uncertain problems, we often choose an appropriate language to describe a fuzzy phenomenon. In 2000, Herrera and Martinez [6] proposed the 2-tuple fuzzy linguistic representation model to deal with qualitative and quantitative data in decision-making problems. This method combines linguistic and numerical information without losing information in aggregating the information. The 2-tuple linguistic representation method comprises the means of a pair of values, (s_i, α), where s_i is a linguistic term and α is a numerical value that represents the symbolic translation [6].

Definition 2.1. [6] *Let $S = \{s_0, s_1, \ldots, s_g\}$ be the initial linguistic term set, and $\beta \in [0, g]$ is a value that represents the result of the symbolic aggregation operation. Then, the 2-tuple that expresses the equivalent information to β can be obtained per the following function:*

$$\Delta : [0, g] \to S \times [-0.5, 0.5) \tag{4}$$

$$\Delta(\beta) = \begin{cases} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-0.5, 0.5) \end{cases} \tag{5}$$

where $round(\cdot)$ is the usual round operation, s_i has the closest index label to β, and α is the value of the symbolic translation.

The comparison of linguistic information represented by 2-tuple fuzzy linguistic representation model is carried out according to an ordinary lexicographic order. Let $(s_i,\ \alpha_1)$ and $(s_j,\ \alpha_2)$ be two 2-tuples, with each one representing the linguistic assessment:

- if $i > j$, then $(s_i,\ \alpha_1)$ is bigger than $(s_j,\ \alpha_2)$.
- if $i = j$, then:

(1) if $\alpha_1 > \alpha_2$, then $(s_i,\ \alpha_1)$ is bigger than $(s_j,\ \alpha_2)$.
(2) if $\alpha_1 = \alpha_2$, then $(s_i,\ \alpha_1)$, $(s_j,\ \alpha_2)$ represent the same information.
(3) if $\alpha_1 < \alpha_2$, then $(s_i,\ \alpha_1)$ is smaller than $(s_j,\ \alpha_2)$.

3. **Proposed Integration of 2-Tuple Model and FAHP Method.** The criteria for selecting students for higher education include academic grades and student ability. Academic grades are quantitative data, and student ability is a type of qualitative data. Dealing with qualitative and quantitative data simultaneously will increase the difficulty of selecting students for higher education, which cannot be solved by arithmetic average method. Moreover, the level of student ability is often fuzzy or a linguistic representation. Under these circumstances, the arithmetic average and AHP methods are inadequate to handle semantic fuzzy information in real-world situations. Thus, to overcome the aforementioned shortcomings, this paper integrates the 2-tuple model and FAHP method to sort student scores.

The proposed approach is organized as follows.

TABLE 2. Membership function of linguistic scales [13]

Linguistic scales	Scale of fuzzy number	Fuzzy number
Equally important (Eq)	(1, 1, 2)	$\tilde{1}$
Weakly important (Wq)	(2, 3, 4)	$\tilde{3}$
Essentially important (Es)	(4, 5, 6)	$\tilde{5}$
Very strongly important (Vs)	(6, 7, 8)	$\tilde{7}$
Absolutely important (Ab)	(8, 9, 9)	$\tilde{9}$
Intermediate values		$\tilde{2}, \tilde{4}, \tilde{6}, \tilde{8}$

Step 1. Set up a hierarchy system, including the goal, criteria, subcriteria, and a set of alternatives.

Step 2. Construct a fuzzy pairwise comparison matrix with triangular fuzzy numbers. The pairwise comparison matrix is organized according to the membership function of linguistic scales to be determined, as shown in Table 2.

Step 3. Calculate the aggregated value using 2-tuple representation.

Step 4. Calculate the fuzzy weights by geometric mean technique. The fuzzy weights of each criterion are computed as follows.

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_n)^{-1}, \text{ for } i = 1, 2, \ldots, n \tag{6}$$

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in})^{1/n}, \text{ for } i = 1, 2, \ldots, n \tag{7}$$

where $\tilde{r}_i$ is the geometric mean of the fuzzy comparison value of criterion i, and $\tilde{w}_i$ is the fuzzy weight of criterion i.

Step 5. Use the center of area (CoA) method for defuzzified fuzzy weights. According to Tzeng and Huang [13], the CoA method for any triangular shape is computed as shown in Equation (5).

$$\text{CoA} = \frac{[(R_i - L_i) + (M_i - L_i)]}{3} + L_i \tag{8}$$

where R_i, L_i, and M_i, represent the right, left, and middle numbers of the triangle of fuzzy numbers, respectively.

Step 6. Calculate the overall priority of the decision alternatives.

Step 7. Analyze the results, and provide suggestions.

4. **Numerical Verification and Comparison.**

4.1. **Overview.** Each university wants to recruit excellent students to maintain its academic reputation and increase its competitiveness. In this section, this paper uses an illustrative example of a scholastic assessment test (SAT) in selecting students for higher education that was drawn from a university in Taiwan to demonstrate our proposed approach. The rating criteria of the SAT include academic grades and student professional ability. With regard to academic grades, there are 4 criteria to evaluate a student's score: Chinese, English, math, and natural science. For student professional ability, 3 commentators assign scores according to an academic grading system (Table 3); the results are shown in Table 4.

Based on Table 2, a pairwise comparison matrix of academic grades and student professional ability is shown in Table 5. With regard to academic grades, pairwise comparison matrixes for the subcriteria are shown in Table 6.

TABLE 3. Academic grading system

Description	Grade
Excellent (Ex)	95
Very Good (Vg)	90
Good (Go)	85
Satisfactory (Sa)	80
Acceptable (Ac)	75
Fail (Fa)	70

TABLE 4. Academic grades and student professional ability of freshmen

Student	Academic grades (C1)				Student professional ability (C2)		
	Chinese (C1.1)	English (C1.2)	Math (C1.3)	Natural science (C1.4)	Commentator 1	Commentator 2	Commentator 3
A	60	53	33	66	Go	Vg	Go
B	80	73	58	66	Fa	Ac	Fa
C	80	60	73	67	Vg	Vg	Go
D	67	67	60	80	Ac	Sa	Sa
E	73	53	47	54	Sa	Sa	Sa
F	67	57	93	73	Go	Go	Sa
G	60	60	62	64	Ac	Sa	Sa
H	88	80	74	87	Ac	Ac	Fa
I	67	60	46	60	Fa	Fa	Ac
J	80	74	60	66	Vg	Go	Go
K	67	73	66	66	Sa	Ac	Ac
L	53	40	53	60	Sa	Ac	Sa
M	80	80	55	80	Go	Go	Vg
N	73	72	67	60	Sa	Sa	Sa
O	80	50	60	67	Go	Go	Vg

TABLE 5. Pairwise comparison matrix between academic grades and student ability

Criteria		C1	C2
C1	Commentator 1	1	(1, 2, 3)
	Commentator 2	1	(2, 3, 4)
	Commentator 3	1	(1, 2, 3)
C2	Commentator 1	(1/3, 1/2, 1)	1
	Commentator 2	(1/4, 1/3, 1/2)	1
	Commentator 3	(1/3, 1/2, 1)	1

4.2. **Solution based on the arithmetic average method.** The arithmetic average method assumes that the criteria and subcriteria are equally weighted. The total average scores for the selection of freshman are shown in Table 7.

4.3. **Solution based on the AHP method.** In the AHP method, the value of the pairwise comparison matrixes for the criteria and subcriteria must be certain and precise. The total average scores for the freshman who were selected by the AHP method are shown in Table 7. The largest eigenvalue of this comparison matrix is $\lambda_{\max} = 4$, and the weights of Chinese, English, math, and natural science were 0.1520, 0.1529, 0.3480, and 0.3480, respectively.

TABLE 6. Pairwise comparison matrix on four subcriteria

Sub-criteria		C1.1	C1.2	C1.3	C1.4
C1.1	Commentator 1	1	(1, 1, 2)	(1/3, 1/2, 1)	(1/3, 1/2, 1)
	Commentator 2	1	(1, 1, 2)	(1/4, 1/3, 1/2)	(1/4, 1/3, 1/2)
	Commentator 3	1	(1, 1, 2)	(1/3, 1/2, 1)	(1/3, 1/2, 1)
C1.2	Commentator 1	(1/2, 1, 1)	1	(1/3, 1/2, 1)	(1/3, 1/2, 1)
	Commentator 2	(1/2, 1, 1)	1	(1/4, 1/3, 1/2)	(1/4, 1/3, 1/2)
	Commentator 3	(1/2, 1, 1)	1	(1/3, 1/2, 1)	(1/3, 1/2, 1)
C1.3	Commentator 1	(1, 2, 3)	(1, 2, 3)	1	(1, 1, 2)
	Commentator 2	(2, 3, 4)	(2, 3, 4)	1	(1, 1, 2)
	Commentator 3	(1, 2, 3)	(1, 2, 3)	1	(1, 1, 2)
C1.4	Commentator 1	(1, 2, 3)	(1, 2, 3)	(1/2, 1, 1)	1
	Commentator 2	(2, 3, 4)	(2, 3, 4)	(1/2, 1, 1)	1
	Commentator 3	(1, 2, 3)	(1, 2, 3)	(1/2, 1, 1)	1

TABLE 7. Total average scores by arithmetic average and AHP methods

Student	Academic grades				Student professional ability				Total average scores	
	Arithmetic average		AHP		Arithmetic average		AHP		Arithmetic average	AHP
	Average	Weight	Average	Weight	Average	Weight	Average	Weight		
A	53.00	0.5	51.63	0.6960	Go	0.5	Go	0.3040	69.00	61.77
B	69.25	0.5	66.41	0.6960	Fa	0.5	Fa	0.3040	69.63	67.50
C	70.00	0.5	70.00	0.6960	Vg	0.5	Vg	0.3040	80.00	76.08
D	68.50	0.5	69.09	0.6960	Sa	0.5	Sa	0.3040	74.25	72.41
E	56.75	0.5	54.30	0.6960	Sa	0.5	Sa	0.3040	68.38	62.11
F	72.50	0.5	76.62	0.6960	Go	0.5	Go	0.3040	78.75	79.16
G	61.50	0.5	62.09	0.6960	Sa	0.5	Sa	0.3040	70.75	67.53
H	82.25	0.5	81.56	0.6960	Ac	0.5	Ac	0.3040	78.63	79.57
I	58.25	0.5	56.19	0.6960	Fa	0.5	Fa	0.3040	64.13	60.39
J	70.00	0.5	67.26	0.6960	Go	0.5	Go	0.3040	77.50	72.65
K	68.00	0.5	67.22	0.6960	Ac	0.5	Ac	0.3040	71.50	69.58
L	51.50	0.5	53.46	0.6960	Sa	0.5	Sa	0.3040	65.75	61.53
M	73.75	0.5	71.30	0.6960	Go	0.5	Go	0.3040	79.38	75.46
N	68.00	0.5	66.24	0.6960	Sa	0.5	Sa	0.3040	74.00	70.42
O	64.25	0.5	63.96	0.6960	Go	0.5	Go	0.3040	74.63	70.35

Then,

$$\text{C.I.} = \frac{\lambda_{\max} - n}{n - 1} = \frac{4 - 4}{4 - 1} = 0$$

$$\text{C.R.} = \frac{0}{0.90} = 0$$

The consistency ratio is less than 0.1, demonstrating that consistency was achieved.

4.4. **Solution based on the FAHP method.** The FAHP method is as an extension of the AHP method. It permits fuzzy or semantic values in assessing freshman. According to Equations (6)-(8), the largest eigenvalue of this comparison matrix is $\lambda_{\max} = 4.0207$, and the weights of Chinese, English, math, and natural science are 0.1710, 0.1508, 0.3597, and 0.3186, respectively.

Then,

$$\text{C.I.} = \frac{\lambda_{\max} - n}{n - 1} = \frac{4.0207 - 4}{4 - 1} = 0.0069$$

$$\text{C.R.} = \frac{0.0069}{0.90} = 0.0077$$

Table 8. Total average scores by FAHP method and the proposed method

Student	Academic grades				Student professional ability				Total average scores	
	FAHP		Proposed method		FAHP		Proposed method		FAHP	Proposed method
	Average	Weight	Average	Weight	Average	Weight	Average	Weight		
A	51.14	0.6787	51.14	0.6787	Go	0.3213	(Go, 1.67)	0.3213	62.02	62.56
B	66.57	0.6787	66.57	0.6787	Fa	0.3213	(Fa, 1.67)	0.3213	67.67	68.21
C	70.33	0.6787	70.33	0.6787	Vg	0.3213	(Vg, –1.67)	0.3213	76.65	76.11
D	68.62	0.6787	68.62	0.6787	Sa	0.3213	(Sa, –1.67)	0.3213	72.28	71.74
E	54.58	0.6787	54.58	0.6787	Sa	0.3213	(Sa, 0)	0.3213	62.75	62.75
F	76.76	0.6787	76.76	0.6787	Go	0.3213	(Go, –1.67)	0.3213	79.41	78.87
G	61.99	0.6787	61.99	0.6787	Sa	0.3213	(Sa, –1.67)	0.3213	67.78	67.24
H	81.44	0.6787	81.44	0.6787	Ac	0.3213	(Ac, –1.67)	0.3213	79.37	78.84
I	56.16	0.6787	56.16	0.6787	Fa	0.3213	(Fa, 1.67)	0.3213	60.61	61.14
J	67.44	0.6787	67.44	0.6787	Go	0.3213	(Go, 1.67)	0.3213	73.08	73.62
K	67.23	0.6787	67.23	0.6787	Ac	0.3213	(Ac, 1.67)	0.3213	69.73	70.26
L	53.27	0.6787	53.27	0.6787	Sa	0.3213	(Sa, –1.67)	0.3213	61.86	61.32
M	71.01	0.6787	71.01	0.6787	Go	0.3213	(Go, 1.67)	0.3213	75.50	76.04
N	66.55	0.6787	66.55	0.6787	Sa	0.3213	(Sa, 0)	0.3213	70.87	70.87
O	64.14	0.6787	64.14	0.6787	Go	0.3213	(Go, 1.67)	0.3213	70.84	71.38

The consistency ratio is less than 0.1; thus, the judgments are acceptable.

The total average scores for the freshman who were selected by the FAHP method are shown in Table 8.

4.5. **Solution based on the proposed method.** In selecting students for higher education, qualitative and quantitative data must be dealt with simultaneously. Moreover, there may be partial loss of valuable information from the commentator in aggregating information on the qualitative data. The proposed method uses a 2-tuple fuzzy linguistic representation model to aggregate the semantic information of the qualitative data. Then, the FAHP method is used to calculate the total average scores for the selected students. In the scholastic assessment test (SAT) example, $S = \{Ex, Vg, Go, Sa, Ac, Fa\}$ and $\alpha \in [-0.25, 0.25)$. The total average scores for the freshman who were selected by the proposed method are shown in Table 8. The largest eigenvalue and the weights of Chinese, English, math, and natural science are the same with the FAHP method. For example, the fuzzy weight of Chinese in academic grade is calculated as follows.

$$\begin{aligned}
\tilde{r}_{1.1} &= (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13} \otimes \tilde{a}_{14})^{1/4} \\
&= \Big((1 \times 1 \times 0.3029 * 0.3029)^{1/4}, (1 \times 1 \times 0.4368 * 0.4368)^{1/4}, \\
&\quad (1 \times 2 \times 0.7937 * 0.7937)^{1/4}\Big) \\
&= (0.5503, 0.6609, 1.0595) \\
\tilde{w}_{1.1} &= \tilde{r}_{1.1} \otimes (\tilde{r}_{1.1} \otimes \tilde{r}_{1.2} \otimes \tilde{r}_{1.3} \otimes \tilde{r}_{1.4})^{-1} \\
&= (0.0928, 0.1520, 0.3440) \\
\text{CoA} &= \frac{[(R_{1.1} - L_{1.1}) + (M_{1.1} - L_{1.1})]}{3} + L_{1.1} \\
&= \frac{[(0.3440 - 0.0928) + (0.1520 - 0.0928)]}{3} + 0.0928 \\
&= 0.1963
\end{aligned}$$

The normalization weight of $w_{1.1}$ is calculated as follows.

$$w_{1.1} = \frac{\tilde{w}_{1.1}}{\tilde{w}_{1.1} + \tilde{w}_{1.2} + \tilde{w}_{1.3} + \tilde{w}_{1.4}} + \frac{0.1963}{0.1963 + 0.1731 + 0.4130 + 0.3658} = 0.1710$$

4.6. **Comparison and discussion.** In order to further illustrate the efficacy of the proposed method, a numerical verification is performed in Section 4. This research also compares the experimental results with the arithmetic average, AHP, FAHP, and proposed methods. The input data of these methods is shown in Tables 3-6. The ranking of the 4 methods is presented in Table 9. Special attributes and the main differences between this paper and the other methods are shown in Table 10. Based on Tables 9 and 10, the proposed method has certain advantages. First, the arithmetic average, AHP, and FAHP methods have a serious shortcoming with regard to partially losing valuable information, which can effect bias conclusions. For example, professional ability scores students A and F are Go in these 3 methods. In the proposed method, the 2-tuple fuzzy linguistic representation (s_i, α) is used to represent the student professional ability score – the score of student A is (Go, 1.67), and that of student F is (Go, –1.67). Thus, the proposed method does not lose any valuable information from the commentator.

Second, qualitative and quantitative data can be dealt with simultaneously. The arithmetic average method only handles quantitative data and cannot solve problems with qualitative data. The AHP, FAHP, and proposed methods used pairwise comparison to deal with decision-making problems. These 3 methods can simultaneously deal with qualitative and quantitative data in selecting students for higher education.

Finally, with regard to the fuzzy information that is considered in aggregating the information, the arithmetic average and AHP methods must have certain and precise scores. These methods can not deal with fuzzy information in selecting students for

Table 9. The ranking of the arithmetic average, AHP, FAHP, and proposed methods

No.	Total average scores				Ranking			
	Arithmetic average method	AHP method	FAHP method	Proposed method	Arithmetic average method	AHP method	FAHP method	Proposed method
A	69.00	61.77	62.02	62.56	12	13	13	13
B	69.63	67.50	67.67	68.21	11	11	11	10
C	80.00	76.08	76.65	76.11	1	3	3	3
D	74.25	72.41	72.28	71.74	7	6	6	6
E	68.38	62.11	62.75	62.75	13	12	12	12
F	78.75	79.16	79.41	78.87	3	2	1	1
G	70.75	67.53	67.78	67.24	10	10	10	11
H	78.63	79.57	79.37	78.84	4	1	2	2
I	64.13	60.39	60.61	61.14	15	15	15	15
J	77.50	72.65	73.08	73.62	5	5	5	5
K	71.50	69.58	69.73	70.26	9	9	9	9
L	65.75	61.53	61.86	61.32	14	14	14	14
M	79.38	75.46	75.50	76.04	2	4	4	4
N	74.00	70.42	70.87	70.87	8	7	7	8
O	74.63	70.35	70.84	71.38	6	8	8	7

Table 10. Special attributes and main differences of the four methods

Method selection	Arithmetic average method	AHP method	FAHP method	Proposed method
Complete information consideration	Partial	Partial	Partial	Yes
Simultaneously deal with the qualitative and quantitative data	No	Yes	Yes	Yes
Fuzzy information consideration	No	No	Yes	Yes

higher education. FAHP and the proposed method use triangular fuzzy numbers to deal with fuzzy information.

5. **Conclusions.** The higher education student selection problem includes qualitative and quantitative data when administering the SAT. The arithmetic average method is widely used in selecting students, because the calculation is simple and easy to understand. However, this method cannot with the qualitative and quantitative data simultaneously. The AHP method can solves this problem, but it is unable to handle the aggregation of semantic fuzzy information. Although FAHP can manage semantic fuzzy information in multicriteria decision-making problems, it loses partial information that is provided by the commentator. To solve these shortcomings, this paper integrates the 2-tuple fuzzy linguistic representation model and FAHP method to sort students' scores. To illustrate the value of the proposed method and compare it with the arithmetic average, AHP, and FAHP methods, the SAT is adopted as an example. Based on our results, the proposed method sorts students more accurately and reasonably in the SAT. Moreover, it does not lose any valuable information from the commentator.

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