Apply Fuzzy AHP to the Principal Selection Systems

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Abstract: In this study, based on fuzzy analytic hierarchy process (fuzzy AHP), constructed of the conditions for the high quality Principal selection. After an overview of literature, finding out the decision factors of the principal selection, and applying fuzzy semantic variables. Then developing of effective tool for the principal selection, finding of the more important factors, and calculating the weights of all levels, to reflect the expectations of the community. Analyzing that decision factors by fuzzy AHP in order to obtain the principal selection.

Keywords: fuzzy AHP, Principal selection, semantic variables

1. Introduction

As the saying goes: "There are how to principals, there is kind of how the school." The school principal is the central figure a leader in the development of school management. How to select a high EQ, intelligent and capable principal to lead school who can positive interact with parents, alumni and the community, establish a very impressive reputation of the school for the benefit of students, that is very important. Therefore, the selection of a good principal is the most critical factor to management a school.

What conditions the quality of principal should have? The proportion of those with the condition are more ? There are different views of each person. According to the literature review, this study was to explore the quality principals should have for the four levels ("Public relations skills.", "Personal leadership skills.", "Personnel management skills.", "Organization functioning skills."). (Chen Su qiu, 2000; Ho Shu Xin, 2009)

There are three indicators under each level. The following is a description of the indicators: 1. the index under "public relations skills" including the "team leader", "relationships", "personality." 2. the index under "personal leadership skills" including "administrative reform", "Vision Management", "continuous improvement." 3. the index under "personnel management skills" including "performance management", "employee motivation", "customer-oriented." 4. the index under "organization functioning skills" including "cultural heritage", "System Planning", "integration management.".

This study was designed to use fuzzy AHP analysis of a questionnaire, and refer to expert opinion. According to the motivation above for the study, the main purpose of this study can be divided into the following three points:

a. Sort all levels and to identify the importance of each index and provides a reference to the relevant units.

b. To whom already be or ready to be the principal specific behavioral indicators.

c. Provide a clear and objective research findings to establish Principal selection system and select high-quality principals.

2. Research Methods

The purpose of this study was to establish Principal selection system, select high-quality principals and explore the weights of each level and select the best principal among suggestions, therefore using fuzzy AHP. It is through the operation of fuzzy numbers, with triangular fuzzy numbers and defuzzification methods to calculate the weight of each criterion, as a reference for select high-quality principals. In these study definitions of statistical analysis with fuzzy data described below:

2.1 Why We Use Fuzzy AHP

Only mean expressed criteria weights will likely lose the criteria weights contained in the part of the message, and it is a very serious problem to use the traditional AHP decision. That is subjectively assessed values or the relative important uncertainly values by decision makers toward factors are deemed to be accurate values to deal with, this is sometimes not very reasonable.

And because these experts and scholars often make decisions in an environment that the target, limitations and the results of possible solutions are not clear, therefore, it may be a good way to use fuzzy linguistic description approach to deal with decision problems. And the weights that determined by each decision makers are not the same, so it should be added to the concept of triangular fuzzy numbers to integrate the opinions of expert groups.

Benefits of using Fuzzy AHP are that less time gathering information and convenience, not many expenditures, and its adaptation to environmental changes, high accuracy, and it can be used in a variety of the decision analysis etc..

2.2 Fuzzy AHP

Definition 2.1 *Fuzzy Numbers*

The set of all real numbers set is normality of a fuzzy subset, and is convex fuzzy subset and a piecewise continuous set of membership functions, Fuzzy numbers are generally divided into triangular fuzzy numbers, Gaussian, trapezoidal fuzzy number, etc. This study with triangular fuzzy numbers carry on the operation, its membership function is defined and illustrated as shown in Fig. 1.(Wu, 2005; Nguyen & Wu, 2006)

$$\mu_{\tilde{T}}(x) = \begin{cases} \dfrac{x-l}{m-l}, & l < x < m \\ \dfrac{u-x}{u-m}, & m < x < u \\ 0, & otherwise \end{cases}$$

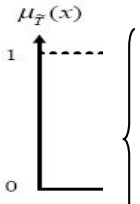


Fig. 1. Triangular fuzzy numbers $\mu_{\tilde{T}}$ membership function

How to select triangular fuzzy numbers? Left and right endpoints of membership functions are 0 , these two points stand for the parental perceptions of the minimum l and maximum u in order to contain parental perceptions. The degree of membership as 1 point stands for the geometric mean of all parental perceptions, because geometric mean value is less susceptible to the influence of discrete value. Triangular fuzzy numbers are with a simple operation, easy to understand and highly practical advantages, It is able to consider the cognitive fuzziness of group decision-making.

Definition 2.2 *Fuzzy linguistic scale*

Because subjective judgment of parents is fuzzy, the usage of linguistic description approach can be easily and fully express their assessed value of subjective judgment. And the usage of triangular fuzzy number expresses evaluation value for each linguistic Statement, so that the process of decision-making adequately represents fuzziness. About fuzzy linguistic scales, if the proposed scale is too few to satisfy the needs of expert. Conversely, if the scale is too many to separate the linguistic differences in scale. Therefore, There are 9 scales in this study according to Miller (1965) suggested more suitable fuzzy linguistic scales of 5-9. Its fuzzy numbers represented by fuzzy linguistic Statement as shown in Table 1, and the graph of membership function as shown in Fig. 2.

Table1 The linguistic variables and their corresponding fuzzy numbers

Intensity of importance	Linguistic Statement	fuzzy numbers
$\tilde{C}_{ij} = \tilde{1}$	equal(E)	(1,1,2)
$\tilde{C}_{ij} = \tilde{2}$	Intermediate values between adjacent scale	(1,2,3)
$\tilde{C}_{ij} = \tilde{3}$	weak importance(WI)	(2,3,4)
$\tilde{C}_{ij} = \tilde{4}$	Intermediate values between adjacent scale	(3,4,5)

$\tilde{C}_{ij} = \tilde{5}$	essential importance(EI)	(4,5,6)
$\tilde{C}_{ij} = \tilde{6}$	Intermediate values between adjacent scale	(5,6,7)
$\tilde{C}_{ij} = \tilde{7}$	very strong importance(VSI)	(6,7,8)
$\tilde{C}_{ij} = \tilde{8}$	Intermediate values between adjacent scale	(7,8,9)
$\tilde{C}_{ij} = \tilde{9}$	absolute importance(AI)	(8,9,9,)

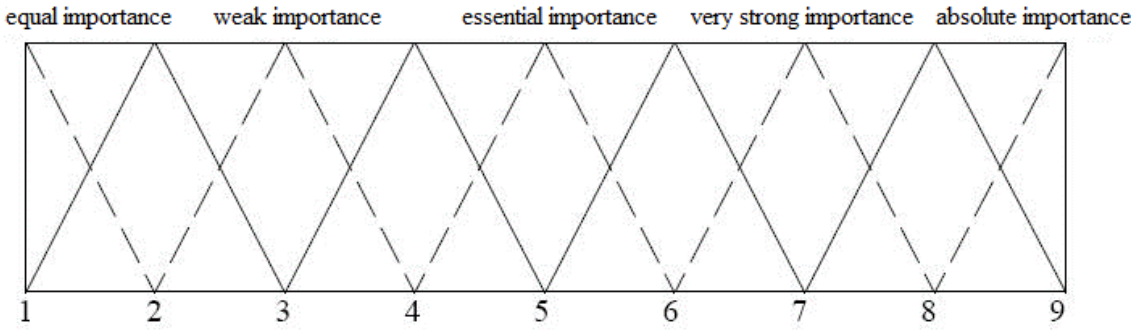
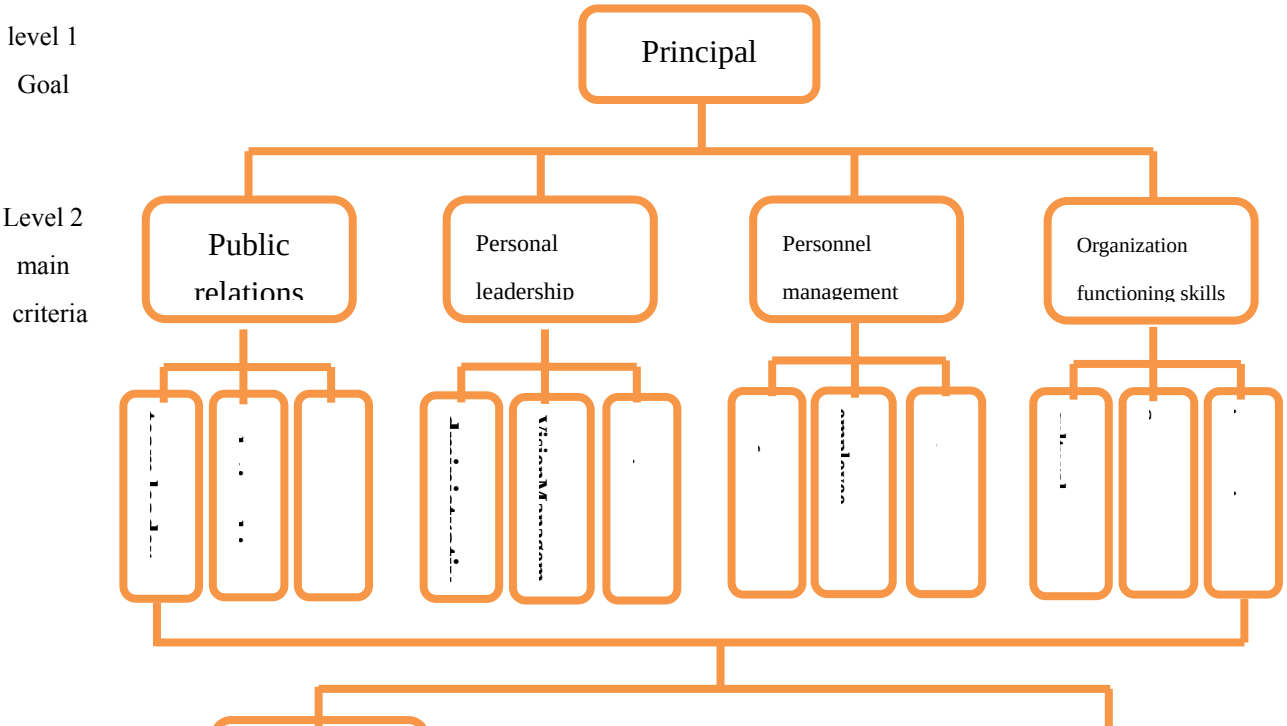


Fig.2. Fuzzy set definition with triangular membership function

2.3 Fuzzy AHP evaluation mode

By archive documents mentioned in each view, and then by the expert interviews, the main criteria for points, "public relations skills," "personal leadership skills," "personnel management skills", "organizational functioning skills," such as the four facets, then follow characteristics of sub-twelve assessment factor. There are two candidate for principal A and B options, level assessment architecture shown in Figure 3 (Lu Shu hui, 2002)



Level 3
evaluation
indicator

Level 4
alternative
choices

Fig. 3. Hierarchical structure for Principal selection

2.4 Designing the questionnaire

According to the hierarchical structure created by the concept of AHP, the questionnaire is designing into pairwise comparison. That get the opinions of experts on the relative importance of pairwise comparison and then to establish pairwise comparison matrices.

2.5 Fuzzy positive reciprocal matrix

Traditionally judgment matrix A= [a_{ij}] is a positive reciprocal matrix, introducing the concept of fuzzy numbers that represents the opinions of experts on the relative importance of pairwise comparison. It Integrates the opinions of experts with triangular fuzzy matrix $\tilde{A} = [\tilde{a}_{ij}]$ so that could establish fuzzy positive reciprocal matrix A.

Definition 2.3 *Establish fuzzy positive reciprocal matrix*

A= [a_{ij}] ，A：Fuzzy positive reciprocal matrix

$\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$

$\tilde{a}_{ij} = \frac{1}{\tilde{a}_{ij}}, \forall i \mid j = 1,2,..., n$

2.6 Organizational Integration

This study used the geometric mean method to integrate the views of principal, the integration equation is as follows:

$$\tilde{a}_{ij} = \left(\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2},..., \otimes \tilde{a}_{ij}^{N}\right)^{\frac{1}{n}}$$

(2.1)

$\tilde{a}_{ij}$ ： Fuzzy positive reciprocal matrix i th column and row j（Triangular fuzzy numbers N）

$\tilde{a}_{ij}^{N}$ ： Expert N for value of the pairwise comparison in the i-th evaluation indicator and the j-th element

2.7 Fuzzy weights calculation

In this study, the fuzzy weight calculation method uses the geometric means method of the rows to operate. Not only calculating weights of fuzzy positive reciprocal matrix by this method, but also obtan the purpose of normalization. This is equation (2-2) and (2-3) can be obtained fuzzy weights.

$$r_i = \left(\tilde{a}_{i1}^{1} \otimes \tilde{a}_{i2}^{2},..., \otimes \tilde{a}_{in}\right)^{\frac{1}{n}}$$

(2.2)

$$\tilde{w}_i = r_i \otimes \left(r_1 \otimes r_2,..., \otimes r_n\right)^{-1}$$

(2.3)

r_i ： geometric means of triangular fuzzy numbers

$\tilde{w}_i$ ： the fuzzy weight of each row for a fuzzy positive reciprocal matrix

2.8 Defuzzification

It must be defuzzification to obtain the clear values of evaluation indicators. This study used anti-triangular fuzzy number equation to get the benefits of objectivity and without decision-makers' preferences added. Calculated as follows：

$$DF_{ij} = \frac{a + b + c}{3}$$

(2.4)

Where l_{ij} is the lower limit value, m_{ij} is the most promising value and u_{ij} is the upper limit value in the triangular fuzzy numbers, respectively.

2.9 Normalization

To compare the different facets and the importance of evaluation indicators, it must normalize the

weights of defuzzification. The process of normalization as follows：

$$DW_i = \frac{DF_{ij}}{\sum DF_{ij}} \quad (2.5)$$

2.10 Series of hierarchical

By the preceding steps, The ith element's weight of the Level 1 below the goal is NW_i ,the jth evaluation indicator's weight of the Level 2 below the ith element is NW_{ij} . It must be carried out series of hierarchical to obtain the jth evaluation indicator's weight of the Level 2 below the goal, series of hierarchical as shown in equation (2-6)：

$$NW_j = NW_i \times NW_{ij} \quad (2.6)$$

3. Empirical analysis

3.1 The respondents are experts

In this study, the data provided by the experts, individually calculate its weight of the assessment target and the consistency test. The C.I. value of pairwise comparison matrix is less than 0.1 and the C.R. value is less than 0.1 as the test standard.

3.2 Analysis the weight of the evaluation indicator

Building the weight of the evaluation indicator in the principal selection system, according to previously established hierarchical structure and the verified data provided from the respondents. So that is obtaining the relative weights of indicators by means of fuzzy AHP. In this section that evaluation indicator of "public relations skills ". As an example, explaining how to convert linguistic scale into values in the questionnaire, how to create a fuzzy positive reciprocal matrix, weight calculation and result analysis.

3.3 Establish positive reciprocal matrix and fuzzy positive reciprocal matrix

Candidate for Principal A as an example, candidate for Principal A for " public relations skills " to express his (her) opinions as shown in Table 2. The positive reciprocal matrix established from data is presented in Table 3, then, the positive reciprocal matrix is converted into fuzzy positive reciprocal matrix, as shown in Table 4. Finally, the next step "Organizational Integration ".

Table 2 Evaluation indicators feedback form Expert A by Public relations skills

A	A:B																B
	AI		VSI		EI		WI		E	WI		EI		VSI		AI	
criterion	9:1	8:1	7:1	6:1	5:1	4:1	3:1	2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	criterion
Team leader							✓											Relationships
Team leader						✓												Personality
Relationships						✓												Personality

Table 3 Positive reciprocal matrix established from Table 2

	Team leader	Relationships	Personality
Team leader	1	3	4
Relationships	1/3	1	4
Personality	1/4	1/4	1

Table 4 Fuzzy positive reciprocal matrix

	Team leader	Relationships	Personality
Team	（1，1，1）	（2，3，4）	（3，4，5）
Relationship	（1/4，1/3，1/2）	（1，1，1）	（3，4，5）
Personality	（1/5，1/4，1/3）	（1/5，1/4，1/3）	（1，1，1）

3.4 Organizational integration of matrix

Using the fuzzy geometric mean method to organizational Integration of matrices for experts （Expert A and Expert B）, in order to get the organizational Integration of fuzzy positive reciprocal matrix, the results shown in Table 5.

Table 5 Organizational Integration of matrices for experts

	Team leader	Relationships	Personality
Team leader	（1，1，1）	(1.71，2.11，2.46)	(2.11，2.46，2.77)
Relationships	(0.41，0.47，0.58)	（1，1，1）	(2.11，2.46，2.77)
Personality	(0.36，0.41，0.47)	(0.36，0.41，0.47)	（1，1，1）

3.5 Calculating weight of evaluation indicators and sorting

Using the equation (2-2) and (2-3) calculating the weight of evaluation indicators, and then by means of defuzzification equation (2-4) to calculate weight of evaluation indicators. Furthermore, this study obtaining the clear weights and rankings of evaluation indicators by normalization of the equation (2-5). That was results as shown in Table 6 (Xiao Yu hua, 2005).

Table 6 The results

	Triangular geometric mean	Fuzzy weight	Defuzzification	Normalization	Ranking
Team leader	（0.99，1.11，1.22）	(0.17，0.21，0.26）	0.21	0.212	3
Relationships	(1.06，1.18，1.31）	(0.18，0.23，0.28）	0.23	0.227	2
Personality	(0.79，0.91，1.04）	(0.14，0.17，0.22）	0.18	0.175	4

Follow the same steps that you can get all the main criteria for the fuzzy weights of principal selection. Finally, the weights of the main criteria and sub-criteria of Level 2 can be series of

hierarchical obtained by equation (2-6). After the overall attribute weights and rankings of sub-criteria are shown in Table 7.

Table 7 The overall attribute weights and rankings of sub-criteria

main criteria and the weight	sub-criteria	Fuzzy weight	Normalization	Separated sorting	Overall attribute	Ranking
Public relations skills 0.273	team leader	(0.17，0.21，0.26)	0.499	1	0.136	1
	relationships	(0.18，0.23，0.28)	0.322	2	0.088	5
	personality	(0.14，0.17，0.22)	0.180	3	0.049	11
Personal leadership skills 0.241	administrative reform	(0.13，0.15，0.17)	0.190	3	0.046	12
	Vision	(0.27，0.31，0.36)	0.306	2	0.074	7
	continuous improvement	(0.21，0.25，0.29)	0.503	1	0.121	2
Personnel management skills 0.239	performance management	(0.17，0.21，0.26)	0.245	3	0.059	10
	employee motivation	(0.18，0.23，0.28)	0.498	1	0.119	3
	customer-oriented	(0.14，0.17，0.22)	0.257	2	0.061	9
Organization functioning skills 0.247	cultural heritage	(0.13，0.15，0.17)	0.322	2	0.080	6
	System Planning	(0.27，0.31，0.36)	0.289	3	0.071	8
	integration management	(0.21，0.25，0.29)	0.389	1	0.096	4

3.6 Alternative choices

According to the questionnaires for evaluation indicators feedback forms, analysing the weight of evaluation indicator in the principal selection system, the results of overall attribute weights and rankings of sub-criteria for Principal candidates are shown in Table 8 . (Chang & Tung, 2004)

3.7 The consistency test

Using EXCEL to calculate the consistency index, the consistency index of all levels is less than 0.1 (Saaty (1996) suggested that less than 0.1), means that experts answered is no inconsistency. The resulting value is reached acceptable consistency, which means that results can be fully expressed views of experts.

Table 8 The result

main criteria and the weight	sub-criteria	Separated sorting	Overall attribute weight	Ranking	Principal A	Principal B
Public relations skills 0.273	team leader	1	0.136	1	90	70
	relationships	2	0.088	5	90	80
	personality	3	0.049	11	90	70
Personal leadership skills 0.241	administrative reform	3	0.046	12	90	70
	Vision	2	0.074	7	90	60
	continuous improvement	1	0.121	2	90	80
Personnel management skills 0.239	performance management	3	0.059	10	90	70
	employee motivation	1	0.119	3	90	80
	customer-oriented	2	0.061	9	90	70
Organization functioning skills 0.247	cultural heritage	2	0.080	6	90	70
	System Planning	3	0.071	8	90	60
	integration management	1	0.096	4	90	80

4. Conclusion

The human mind can have a logical and sequential nature of the "formal thinking" (formal thinking), it may be holistic and comprehensive "fuzzy thinking" (fuzzy thinking). For a person to evaluate the quality of "fuzzy thinking" should be more appropriate, because the degree of personal preference to another, the value may not be accurate to blur mode to specify a single value than direct, more appropriate to a single object, and therefore the "fuzzy theory" constructivism principal selection index system is very reasonable.

Indeed, the selection of high-quality school principals to management and sophisticate educational outcomes is important link, principal selection is a multi-attribute decision-making problems, due to become qualitative of the selection criteria, and assessment of personnel easily caught subjective judgment implied ambiguity, Therefore, this study fuzzy AHP constructed system of selection of principals, aims to develop an effective and objective to provide a reference tool for the selection and assessment of those decisions.

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