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Fuzzy multi-attribute decision making for students achievement selection using e-technology

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Abstract: The determination of student achievements (Pilmapres) level from the faculty sometimes face problems when certain criterias on the candidates does not meet, but on the other hand criteria assessment obtained exceeds the requirements, also when the data or information provided both by the jury and data criteria of the candidates are incomplete or contain uncertainty which lead to uncertain value. So therefore the aim of this study is to use fuzzy MADM method technique for order preference by similarity to ideal solution (TOPSIS) to determine the best performing students in the faculty level. Results of this research is the application of fuzzy MADM with TOPSIS method to support decision making in the selection of outstanding students with a faculty level candidates from as many as 20 students.

Keywords: fuzzy MADM; TOPSIS; Pilmapres.

1. Introduction

Multi-criteria decision making (MCDM) is a decision making method to establish the best alternative from a number of alternatives based on several criterias. Based on its objective, MCDM can be divided into two models [1-3]. MCDM is a decision making method to establish the best alternative from a number of alternatives based on certain criterias [4-6]. Based on the MCDM goal it is divided into two models: Multi-attribute decision making (MADM); and multi-objective decision making (MODM) [7-9]. MADM is used to make the selection of a number of alternatives in limited quantities while MODM is used to design the best alternative (e.g., Ashraf et al., 2016; Bahiraei et al., 2015; Wang and Ji, 2014; Gong et al., 2013; Mohyeddin and Gharaee, 2014) [10-11]. If the data or information provided both by the jury and data criteria of candidates are incomplete or contain uncertainty, then to address the issue of uncertainty we utilise the fuzzy MCDM method called fuzzy MADM and fuzzy MODM (Kusumadewi and Purnomo, 2010; Kusumadewi et al., 2006) [12-15]. Selection of the best students, an activity to select or search for and provide awards to students who achieved high achievements in both curricular and extra curricular in accordance with the criteria specified (Risetdikti, 2017) [16-19]. The purpose of this study is to utilise the fuzzy MADM method to determine the best performing student faculty level [20].

2. Theoretical setting

2.1 Fuzzy Sets and Fuzzy Numbers

Definitions 1 :

A fuzzy set in X is defined by : A = {x, μ A (x)}, x ∈ X …………Equation 1

in which $\mu A(x)$: $X \rightarrow [0, 1]$ is the membership function of A and $\mu A(x)$ is the degree of membership of x in A. If $\mu A(x)$ equals 1, x completely belongs to fuzzy set A. Unlike in classical set theory, $\mu A(x)$ may be a value between zero and one, capturing partial membership of x in the fuzzy set A (Zadeh, 1965).

Definition 2:

A fuzzy number M is a convex normal fuzzy set M of the real line R such that Zimmermann (1992). There exists exactly one $x\ 0 \in R$ with $\mu M\ (x\ 0) = 1$ ($x\ 0$ is called mean value of M) and $\mu M(x)$ is continuous. The triangular fuzzy number (TFN) is most widely used in decision making because of its intuitive membership functions and computational simplicity (Erturul and Karakaolu, 2007; Lima et al., 2014). In this study, TFNs are adopted in both of the fuzzy technique for order preference by similarity to ideal solution (TOPSIS) methods. TFN can be defined as a triplet (l, m, u). The parameters l, m and u, respectively, specify the smallest possible value, the peak value and the largest possible value of the membership function.

2.2 Fuzzy multi-attribute decision making

Fuzzy multi-attribute decision making (FMADM) has a specific purpose, which can be classified into two types (Simoes-Marques et al., 2000). There are some methods that can be used to solve the problem FMADM as follows (Kusumadewi et al., 2006):

1. Simple Additive Weighting (SAW)
2. Weighted Product (WP)
3. ELECTRE
4. TOPSIS
5. Analytic Hierarchy Process (AHP).

This research utilises fuzzy TOPSIS.

2.3 Technique for order preference by similarity to ideal solution

TOPSIS based on the concept that the best alternative was selected not only does it have the shortest distance from the positive ideal solution, but it also has the longest negative ideal solution from the distance (Kusumadewi et al., 2006). In general, TOPSIS procedure is following the steps as follows:

1. make a decision matrix that is normalised.
2. make a decision matrix that is normalised weighted.
3. determine the ideal solution matrix of positive and negative ideal solution matrix.
4. determine the distance between the value of each alternative with the ideal solution matrix positive and negative ideal solution matrix.
5. determining the value of preference for each alternative.

TOPSIS require the rating of performance for each alternative Ai , on each criterion Cj that are normalised as

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad \text{with } i = 1, 2, \ldots, m; \quad j = 1, 2, \ldots n \qquad (2)$$

$\mathbf{A}^+$ positive ideal solution and negative ideal solution $\mathbf{A}^-$ rating weights can be determined based on the normalised ($\mathbf{y}_{\mathbf{ij}}$) :

$$y_{ij} = w_i r_{ij} \quad \text{with } i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n. \tag{3}$$

$$A^{+} = \left(y_1^{+} + y_2^{+}, \ldots, y_n^{+}\right); \tag{4}$$

$$A^{-} = \left(y_1^{-}, y_2^{-}, \ldots, y_n^{-}\right); \tag{5}$$

With:

$$y_j^{+} = \begin{cases} \max\limits_i y_{ij}; & \text{If } j \text{ is profit attribute} \\ \min\limits_i y_{ij}; & \text{If } j \text{ is fee attribute} \end{cases} \tag{6}$$

$$y_j^{-} = \begin{cases} \min\limits_i y_{ij}; & \text{If } j \text{ is fee attribute} \\ \max\limits_i y_{ij}; & \text{If } j \text{ is fee attribute} \end{cases} \tag{7}$$

$j = 1, 2, \ldots n.$

The distance between the alternative Ai with a positive ideal solution is formulated as:

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} \left(y_i^{+} - y_{ij}\right)^2}; \quad i = 1, 2, \ldots, m \tag{8}$$

The distance between the alternative Ai with negative ideal solution is formulated as:

$$D_i^{-} = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_i^{-}\right)^2}; \quad i = 1, 2, \ldots, m. \tag{9}$$

Preference value for each alternative (V i) is as follows:

$$V_i = \frac{D_i^{-}}{D_i^{-} + D_i^{+}}; \quad i = 1, 2, \ldots, m \tag{10}$$

Vi larger value indicates that the preferred alternative is Ai .

3. Data and methodology

3.1 Data

The data used in this paper is obtained from the students of the Faculty of Information and Communication Technology University of Semarang, in 2013 the student body. Total student data used is 20 data samples taken randomly. The criteria used to determine student achievement is the GPA (C1), essay (C2), achievement/ability underdog (C3), English/foreign language (C4).

3.2 Methodology

The following shows the flowchart in Figure 1, step 1 which determines the criteria, Stage 2 to specify a rating of matches for each criterion, stage 3 forming Fuzzy membership functions for each criterion, stage 4 form a matrix decision (X), stage 5 Determining the weights of preferences (W) to each criterion, stage 6 determines the decision matrix (X) be a weighted normalised decision matrix (R), stage 7 to Determine the distance between the value of each alternative with the ideal solution matrix positive and negative ideal solution, stage 8 determines the preference value for each alternative. The steps undertaken in this study are shown in Figure 1.

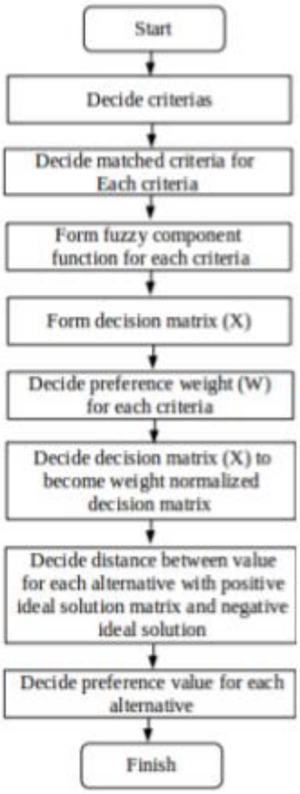


Figure 1.Research flow

3.2.1 Determining criteria

Determination of suitability rating criteria of each alternative on the GPA from 0 to 1, can be seen in table 1.

Table 1 Cumulative index grade point average (GPA) value

GPA	*Grades*
GPA <= 2.75	0
2.75 < X <= 3.00	0.25
3.00 < X <= 3.25	0.5
3.25 < X <= 3.50	0.75
GPA > 3.50	1

Determination of suitability rating of each alternative on the criteria of research value from 0 to 1, can be seen in table 2.

Table 2 Weight of the value of research

Research grade	*Grade*
Grade <= 50	0
60 < X <= 70	0.25
70 < X <= 80	0.5
80 < X <= 90	0.75
Grade > 90	1

Determination of suitability rating criteria of each alternative on achievement scores from 0 to 1, it can be seen in table 3.

Table 3 Weight value of achievement

Achievement score	*Grades*
Score <= 50	0
60 < *X* <= 70	0.25
70 < *X* <= 80	0.5
80 < *X* <= 90	0.75
Score > 90	1

Determination of suitability rating criteria of each alternative on English language proficiency score from 0 to 1, looks like Table 4.

Table 4 Weight of English language proficiency score

English proficiency score	*Grades*
Score <= 50	0
60 < *X* <= 70	0.25
70 < *X* <= 80	0.5
80 < *X* <= 90	0.75
Score > 90	1

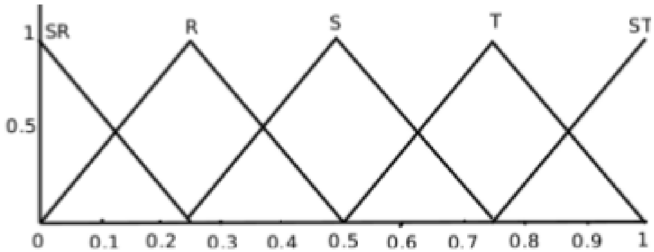
3.2.2 Constructing the fuzzy membership function

Each criterion is then made variable. Predefined variables will be converted into fuzzy numbers. Fuzzy numbers formed are:

1. very low (SR) = 0
2. low (R) = 0:25
3. medium (M) = 0.5
4. height (T) = 0.75
5. very high (ST) = 1

Figure 2 shows the membership function of each criterion:

Figure 2 Component function of each criteria



4. Result of student outstanding achievement selection

The following alternatives outstanding students unrated the tabulated suitability of each criterion are presented in table 5.

Table 5 Rating suitability of each alternative on each criterion

Name	*Criteria*			
	C1	*C2*	*C3*	*C4*
Student A	0.5	0.5	0.5	0.5
Student B	0.5	0.25	0.5	0.5
Student C	0.75	0.25	0.5	0.75
Student D	0.5	1	0.75	0.75
Student E	0.75	0.5	0.5	0.25
...	...	...	...	...
Student T	0.75	0.5	0.5	0.5

4.1 Decision matrix forming (X)

Decision matrix formed in accordance with the table matches and fuzzy set membership functions. The following data is taken randomly from all the data available alternatives:

$$\text{Matrix } X = \begin{vmatrix} 0.5 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.25 & 0.5 & 0.5 \\ 0.75 & 0.25 & 0.5 & 0.75 \\ 0.5 & 1 & 0.75 & 0.75 \\ 0.75 & 0.5 & 0.5 & 0.25 \\ 0.75 & 0.5 & 0.5 & 0.5 \end{vmatrix}$$

4.2 Determining the weight of preference (W) for each criteria

Preference weights determined according to the decision makers, namely:

1. GPA (C1) = 0.5
2. essay (C2) = 1
3. achievement/capabilities are seeded (C3) = 0.75
4. English/foreign language (C4) = 0.5

The weight vector (W) = [0.5 1 0.75 0.5]

4.3 Conducting decision matrix normalisation (X)

Decision matrix is normalised into normalised matrix (R). Here are the results for data normalisation outstanding students selected, based on equation (2):

$$R = \begin{vmatrix} 0.4264 & 0.0006 & 0.6396 & 0.6396 \\ 0.6396 & 0.0006 & 0.0006 & 0.6396 \\ 0.4264 & 0.4264 & 0.4264 & 0.4264 \\ 0.2132 & 0.4264 & 0.4264 & 0.4264 \end{vmatrix}$$

4.4 Perform ranking process (V)

Ranking process conducted by equation (8), the resulting ranking process is as follows:

$$V1 = \frac{0.398843}{0.398843 + 0.049751} = 0.889094$$

$$V2 = \frac{0.359995}{0.359995 + 0.097377} = 0.787094$$

$$V3 = \frac{0.232221}{0.232221 + 0.201760} = 0.535095$$

$$V4 = \frac{0.233298}{0.233298 + 0.239005} = 0.493959$$

$$V5 = \frac{0.293967}{0.293967 + 0.421333} = 0.410970$$

The results of ranking the best students of all data that is then sorted by the largest value, is as in Table 6.

Table 6 Result of ranking the best students

Name	*C1*	*C2*	*C3*	*C4*	*Score*
Student I	0.75	1	1	0.75	0.889094
Student D	0.5	1	0.75	0.75	0.787094
Student F	0.5	0.75	0.5	0.5	0.535095
Student O	0.5	0.5	1	0.5	0.493959
Student R	0.5	0.75	075	1	0.410970

5. Conclusions

Based on the results of the stages in this study, it can be concluded. The criteria for the best students they can be presented into fuzzy MADM by using fuzzy TOPSIS for selection of outstanding students, student I have numbered the first achievement to get the value of 0.889094, student D achievement serial number both get the value 0.787094, student F has a serial number of achievements third gain value of 0.535095, students O have numbered the fourth achievement scores of students 0.43959 and R have the serial number of the fifth achievement scores 0.410970 model of decision making in determining student achievement by using FMADM with TOPSIS method can give accurate results.

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