

The Effectiveness of Fuzzy-SAW Method for the Selection of New Student Admissions in Vocational High School

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ABSTRACT

New student admission activities are routine activities carried out by vocational high schools every year to get the best students. A method is needed that can be used as a means of screening to select students based on their abilities and fields that are in accordance with the characteristics of students. This study uses the Fuzzy-SAW Method which is carried out through 3 stages, namely preparation of the components of the situation, the analysis and synthesis of information. The use of this method is expected to be able to help and provide the best decisions in the acceptance of new students.

I. INTRODUCTION

Along with the development of science in the era of globalization, the world of education also competes to improve the quality of education in order to develop its institutions and also to win the competition. This will lead to an increasingly fierce level of competition, requiring school management to take policies so that schools can survive in competition. The success of educational institutions' implementation will be very dependent on the supporting components of the implementation of activities such as: curriculum, students, staff funding and infrastructure. The success of organizing educational institutions will depend on the management of students. Management of students provides a high contribution and strong support for other components in educational institutions in achieving institutional goals.

The existence of components of students is needed by educational institutions. Moreover, in the implementation of educational activities in schools, students are the subject and object in the process of transformation of the necessary knowledge and skills. Therefore, the existence of students is not only to meet the needs, but must be part of the success of educational institutions.

One of the activities in the management of students is the acceptance of new students. Students can be accepted in an educational institution if they have met the requirements as specified. There are two systems used in accepting new students. First, by using a promotion system. Promotion system is done without using selection. Students who register are accepted without prior selection so that no one is rejected. Promotion systems generally apply to schools where registrants are less than the specified capacity. Second, by using a selection system. The selection system can be classified into three types, namely: selection based on school grades, selection based on the search for interests and abilities, and selection based on the results of the entrance test.

SMK Telkom Malang uses 6 criteria for Selection of new students, such as the value of academic tests for subjects in mathematics, physics, and English, as well as parent's income, participants interest, and fitness test. SMK Telkom Malang has implemented a decision support system using the SAW method for new student admissions, but the results are still not optimal, so a new program is created with the Fuzzy-SAW method that is expected to be able to overcome this problem.

This study aims to develop a program that is able to act as a decision support system in determining prospective new student

candidates at SMK Telkom Malang more objectively and efficiently.

II. RELEVANT RESEARCH

Several previous studies have applied the Fuzzy-SAW Method to the same problem. The first research is "Fuzzy Multi Attribute Decision Making–Simple Additive Weighting (MADM-SAW) for Information Retrieval (IR) in E-Commerce Recommendation". This research produces a fuzzy multi attribute decision making-simple additive weighting (MADM-SAW) model for information retrieval (IR) on ecommerce recommendations, where fuzzy calculation results are the alternative end value in e-commerce recommendations. The research method used in this research is the Research and Development (R&D) method that is only done on trial product or limited trial only. So then, based on the experimental results, it is found that content not only matches the search query, but there is also a comparative information about the satisfactory value of the product feedback and reviews, the reputation of the online shop, the reliable price of the product, and the number of products sold from the online store [1].

The second study is "Fuzzy Simple Additive Weighting Method in the Decision Making of Human Resource Recruitment". This research was conducted by finding the weight values for each attribute. Then do the ranking process that determines the optimal alternative to the best applicants who qualify as employees of the company. Based on calculations by the SAW obtained the two highest ranking results are A5 (alternative 5) and A1 (alternative 1), to obtain two candidates received [2].

The third study is "Fuzzy Simple Additive Weighting and its Application to Toddler Healthy Food". There are six criteria used in this study are: (1) Food Staple, (2) Vegetables, (3) Fruits, (4) Nuts, (5) Side dishes, (6) Milk and, (7) Food interlude. From these studies, there are three alternatives highest value V3 with a value of 0.69, V5 with a value of 0.655 and V6 with a value of 0.71 and three alternatives are selected as the best alternative that otherwise meet the criteria of healthy food for toddlers [3].

The fourth study is "The Selection of New Students RSBI Using Fuzzy SAW Based Application". From the system test conducted using prospective student data has an accuracy of 95.8% and 91.7% of data applicants RSBI prospective students. The results of this accuracy are compared with actual student acceptance [4].

The fifth research is "Project manager selection by using Fuzzy Simple Additive Weighting Method". By implementing Fuzzy Simple Additive Weighting (SAW) method for selecting project manager in MAPNA Company a multi criteria decision making (MCDM) method was conducted in this paper as part of an extensive research. The feedbacks reveal that this model is quite reliable in selecting project managers and can ameliorate the efficiency of decision-making process [5].

The sixth research is "Prioritizing the teaching methods of ESD using an integrated fuzzy entropy–SAW algorithm (case study: technical and vocational schools)". This research intends to find the best teaching method of education for sustainable development (ESD) in order to improve the behavior of those

graduates toward the environment. For this purpose, the fuzzy entropy method was used to introduce and weight the sustainable development competency criteria of the T&V graduates. Then, the teaching methods were prioritized by applying a fuzzy Simple Additive Weighted (SAW) model. According to the results of the present paper, performance-based learning was the most appropriate method of ESD [6].

The seventh research is "Application of Fuzzy Linguistic SAW and TOPSIS Multiple Criteria Group Decision Making Method using Pentagonal Fuzzy Number for Supplier Selection Problem". In this paper, the study is about the integration of fuzzy linguistic SAW and TOPSIS with the support of pentagonal fuzzy number. The proposed SAW and TOPSIS method are a ground decision maker to rank the candidate alternative more efficiently and easily. The verified example concerning the supplier selection shows that the SAW and TOPSIS method is very useful for the selection of best alternatives [7].

The eighth study is "Rule Model with Fuzzy Simple Additive Weighting Approach and Weighted Product on Determination of Position in High Education Institution". The result of the use of SAW and WP Method resulted in the same results of the same result of Alternative 1 was decided as the eligibility to occupy the position of Chairman A very important indicator in the selection is the level of education and years of service. The results of the use of SAW and WP Methods obtain more accurate results, optimal and not subjective. The result of comparison of SAW Manual and Program amounted to 4,529,418, and the comparative amount of manual WP calculation and program normalization value amounted to 0.051343, while manual calculation of WP and program value of vector totaled 0.004759 [8].

The ninth research is "The Application of Decision Support System by Using Fuzzy Saw Method in Determining The Feasibility Of Electrical Installations In Customer's House". This study used Fuzzy Logic to determine the criteria and the desired weight in determining the installed extension to the customer's house, based on the criteria that exist in National Committee of Safety for Electrical Installation. The calculation results obtained with the highest value is V5 is the circuit breaker with the total value = 3 [9].

The tenth research is "Fuzzy MADM Approach of Stock Ranking and Portfolio Selection in Tehran Stock Exchange". This study proceeds to review the issues related to the selection and stock ratings-based approach FMADM in the Tehran Stock Exchange [10]. Stocks in portfolio ranked based on FAHP and FSAW methods, and showed that the computed rank of selected stocks in portfolio with fuzzy analytic hierarchy process (FAHP) method in comparison with computed rank of selected stocks in portfolio with fuzzy simple additive weighting method didn't have differential result and the investors can select the criteria for portfolio selection whether FAHP or FSAW.

Based on the results of the ten studies above, it can be concluded that the system or application that applies the Fuzzy-SAW Method can be used as a decision support in determining new students accepted by the school. The ten studies show that the system built with Fuzzy-SAW shows accurate results when compared with expert results.

III. METHOD

A. Decision Support System

Decision support system is a system that helps decision-makers to supplement the information from the data that has been processed by the relevant and necessary to make a decision about a problem more quickly and accurately.

Decision support systems are interactive, computer-based systems that aid users in judgment and choice activities. They provide data storage and retrieval but enhance the traditional information access and retrieval functions with support for model building and model-based reasoning. They support framing, modeling, and problem solving [11].

Typical application areas of DSSs are management and planning in business, health care, the military, and any area in which management will encounter complex decision situations. Decision support systems are typically used for strategic and tactical decisions faced by upper-level management-decisions with a reasonably low frequency and high potential consequences-in which the time taken for thinking through and modeling the problem pays off generously in the long run.

B. SAW

Simple Additive Weighting (SAW) which is also known as weighted linear combination or scoring methods is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of magnitude of the standardized scores remains equal [12].

C. Fuzzy Tsukamoto

Tsukamoto method first introduced by Tsukamoto, 1979, which is one of the methods of decision-making. This method applies to any used monotone reasoning rule, the intention is to use the system with only one rule. The implications of each rule in the form of implications "Cause and Effect" or Implications "Input-Output" in which the antecedent and the consequent has to be related. Each rule is represented using fuzzy associations, with monotonous membership function. Then, to determine the outcome of a firm (Crisp Solution) is used with formulas assertion (defuzzification) called "centered average method". There are three steps in using the Tsukamoto method which are (1) Fuzzification, (2) Inference, and (3) Defuzzification.

This formulation is to determine the crisp output value that will be the number of goods produced (Z), by changing the input (in the form of fuzzy sets derived from the composition of fuzzy rules) into a number of fuzzy sets in the domain [13].

D. Fuzzy Multi Attribute Decision Making (Fuzzy MADM)

The selection of new students at SMK Telkom Malang uses six criteria. The academic field include math test, physics test, and English test. While the non-academic include parent's income, participants interest, and fitness test. The criteria taken

into consideration in the selection of new students as in Table 1.

Basically, the FMADM process is carried out through 3 stages, namely: preparation of situation components, analysis, and information synthesis. There are several methods that can be used to solve FMADM problems, such as:

1. Simple Additive Weighting Method (SAW).
2. Weighted Product (WP).
3. ELECTRE.
4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).
5. Analytic Hierarchy Process (AHP).

This research uses FMADM with SAW. The steps are as follows:

1. Determine the criteria that will be used as a reference in making decisions, namely C_i .
2. Determine the suitability rating of each alternative on each criterion.
3. Make a decision matrix based on criteria (C_i), then normalize the matrix based on equations adjusted for the type of attribute (attribute gain or cost attribute) so that the normalized matrix is obtained.
4. The final results are obtained from the ranking process, namely the sum of multiplication of normalized matrix R with the weight vector so that the largest value is chosen as the best alternative (A_i) as a solution.

IV. RESULT AND DISCUSSION

The selection of new students at SMK Telkom Malang uses six criteria. The academic field include math test, physics test, and English test. While the non-academic include parent's income, participants interest, and fitness test. The criteria taken into consideration in the selection of new students as in Table 1. Then, the weight of each criteria for the selection of new students is shown in Table 2.

TABLE I. STUDENT ADMISSIONS CRITERIA

Criteria	Name of Criteria
C1	Math test score
C2	Physics test score
C3	English test score
C4	Parent's income
C5	Participant's interest
C6	Fitness test

TABLE II. CRITERIA WEIGHT

Criteria	Name of Criteria
C1	17%
C2	10%
C3	13%
C4	30%
C5	25%
C6	5%

Criteria C1, C2, C3, C4, and C6 will produce 4 fuzzy values, namely: Very Low (VL), Low (L), Medium (M), and High (H).

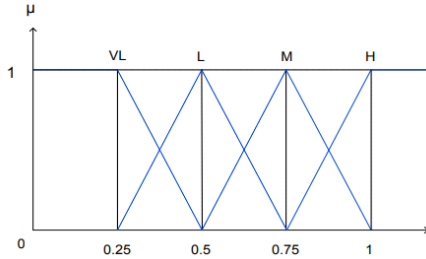


Fig. 1. Overview of fuzzy linguistic variables for Math (C1), Physics (C2), English (C3) Test Score, Parent's Income (C4), and Fitness Test (C6)

TABLE III. FUZZY LINGUISTIC VARIABLES AND THEIR CORRESPONDENT FUZZY VALUE FOR MATH (C1), PHYSICS (C2), AND ENGLISH (C3) TEST SCORE

Score	Linguistic terms	Linguistic values
<50	Very low	0.25
50-70	Low	0.5
71-85	Medium	0.75
>85	High	1

TABLE IV. FUZZY LINGUISTIC VARIABLES AND THEIR CORRESPONDENT FUZZY VALUE FOR PARENT'S INCOME (C4)

Parent's income	Linguistic terms	Linguistic values
<2.000.000	Very low	0.25
2.000.000-5.000.000	Low	0.5
5.000.000-10.000.000	Medium	0.75
>10.000.000	High	1

TABLE V. FUZZY LINGUISTIC VARIABLES AND THEIR CORRESPONDENT FUZZY VALUE FOR FITNESS TEST (C6)

Fitness test	Linguistic terms	Linguistic values
<2	Very low	0.25
2-4	Low	0.5
4-6	Medium	0.75
>6	High	1

Criteria C5 will produce 3 fuzzy values, namely: Low (L), Medium (M), and High (H).

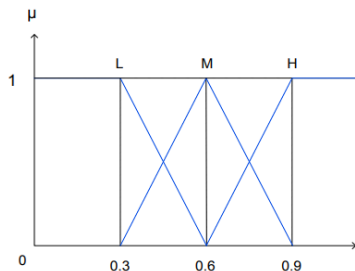


Fig. 2. Overview of fuzzy linguistic variables for Participants Interest (C5)

TABLE VI. FUZZY LINGUISTIC VARIABLES AND THEIR CORRESPONDENT FUZZY VALUE FOR PARTICIPANTS INTEREST (C5)

Participant's interest	Linguistic terms	Linguistic values
<18	Low	0.3
18-24	Medium	0.6
>24	High	0.9

The following will be elaborated on Fuzzy-SAW manual calculations for 10 prospective students. Examples of data used can be seen in Table 7.

TABLE VII. SAMPLE DATA FOR MANUAL CALCULATION

Code name	Criteria					
	C1	C2	C3	C4	C5	C6
A1	90	70	95	7.000.000	28	4
A2	85	80	70	10.000.000	32	5
A3	50	65	80	4.000.000	18	2
A4	60	90	90	15.000.000	17	6
A5	70	50	75	5.000.000	28	7
A6	45	60	60	12.000.000	25	1
A7	95	80	70	25.000.000	10	2
A8	85	85	50	3.000.000	23	3
A9	65	70	95	2.000.000	12	4
A10	75	45	90	6.000.000	10	4

The next step is to form a suitability rating for each alternative for each criterion as shown in Table 8.

TABLE VIII. SUITABILITY RATING

Code name	Criteria					
	C1	C2	C3	C4	C5	C6
A1	1	0.5	1	0.75	0.9	0.75
A2	0.75	0.75	0.5	0.75	0.9	0.75
A3	0.25	0.5	0.75	0.5	0.3	0.5
A4	0.5	1	1	1	0.3	1
A5	0.5	0.25	0.75	0.5	0.9	1
A6	0.25	0.5	0.5	1	0.9	0.25
A7	1	0.75	0.5	1	0.3	0.5
A8	0.75	0.75	0.25	0.5	0.6	0.5
A9	0.5	0.5	1	0.25	0.3	0.75
A10	0.75	0.25	1	0.75	0.3	0.75

The next step is to make a decision matrix and normalized matrix. The following is an example of a Decision Matrix made from Suitability Rating.

$$X = \begin{bmatrix} 1 & 0.5 & 1 & 0.75 & 0.9 & 0.75 \\ 0.75 & 0.75 & 0.5 & 0.75 & 0.9 & 0.75 \\ 0.25 & 0.5 & 0.75 & 0.5 & 0.3 & 0.5 \\ 0.5 & 1 & 1 & 1 & 0.3 & 1 \\ 0.5 & 0.25 & 0.75 & 0.5 & 0.9 & 1 \\ 0.25 & 0.5 & 0.5 & 1 & 0.9 & 0.25 \\ 1 & 0.75 & 0.5 & 1 & 0.3 & 0.5 \\ 0.75 & 0.75 & 0.25 & 0.5 & 0.6 & 0.5 \\ 0.5 & 0.5 & 1 & 0.25 & 0.3 & 0.75 \\ 0.75 & 0.25 & 1 & 0.75 & 0.3 & 0.75 \end{bmatrix}$$

The Normalized Matrix is made using the following calculation:

For Benefit

$$r_{11} = \frac{1}{\text{Max}(1, 0.75, 0.25, 0.5, 0.5, 0.25, 1, 0.75, 0.5, 0.25)}$$

$$r_{11} = \frac{1}{1} = 1$$

The normalization matrix results are as follows:

$$X = \begin{bmatrix} 1 & 0.5 & 1 & 0.75 & 1 & 0.75 \\ 0.75 & 0.75 & 0.5 & 0.75 & 1 & 0.75 \\ 0.25 & 0.5 & 0.75 & 0.5 & 0.33 & 0.5 \\ 0.5 & 1 & 1 & 1 & 0.33 & 1 \\ 0.5 & 0.25 & 0.75 & 0.5 & 1 & 1 \\ 0.25 & 0.5 & 0.5 & 1 & 1 & 0.25 \\ 1 & 0.75 & 0.5 & 1 & 0.33 & 0.5 \\ 0.75 & 0.75 & 0.25 & 0.5 & 0.67 & 0.5 \\ 0.5 & 0.5 & 1 & 0.25 & 0.33 & 0.75 \\ 0.75 & 0.25 & 1 & 0.75 & 0.33 & 0.75 \end{bmatrix}$$

The example of V calculations for the ranking:

$$V1 = (1)(0.17) + (0.5)(0.10) + (1)(0.13) + (0.75)(0.30) \\ + (1)(0.25) + (0.75)(0.5)$$

$$V1 = 0,86$$

Based on calculations such as in the example above, the results and ranking are obtained as in Table 9.

TABLE IX. ASSESSMENT RESULT

Code name	Value	Rank
A1	0.86	1
A2	0.78	2
A3	0.45	10
A4	0.75	3
A5	0.66	6
A6	0.72	4
A7	0.72	5
A8	0.58	8
A9	0.46	9
A10	0.63	7

One reason to use fuzzy algorithms is because the classical database (not using fuzzy) only handles data that is certain and firm. Whereas in reality humans often communicate in languages that have no clear boundaries or can be said to have ambiguous values. To deal with this, a database was built with the fuzzy logic approach to be a very suitable choice. Based on the calculation results it appears that the Fuzzy-SAW algorithm is more effectively applied than the SAW algorithm. According to Mustaqim, et al, Cholid A.A., et al and Praseyo D, et al that a system that has good quality can be used for a long period of time [14], [15], [16]. The developed system also meets the system construction criteria by Sriardhi, namely program performance [17].

V. CONCLUSIONS

The Fuzzy-SAW method can be applied as a solution to determine new students in SMK Telkom Malang. From around 1000 data on new student admissions in 2018 tested, the output of the system shows that using the Fuzzy-SAW method has an accuracy of more than 85% when compared to the SAW method with an accuracy of 80%.

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