Fuzzy Multi Attribute Decision Making for Major Selection at Senior High School

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Abstract— **The major selection of high school students is not only determined on the basis of academic ability but also supported by the interest factor. Students who study a science which suit their characteristics would feel excited when learning the sciences as well as having much influence in academic achievement positively. The purpose of this study is to optimize the process of major selection on the level of senior high school. The model used in the system of decision support was Fuzzy Multiple Attribute Decision Making (FMADM) by the method of Simple Additive Weighting (SAW). SAW method is selected for this decision support system because this method determines weights for each attribute, then it is followed by ranking process that will select the best alternative from a number of alternatives.The technique of Fuzzy Multiple Attribute Decision Making (FMADM) has the role to accommodate the presence of uncertainty in decision making by providing the value of structured preferences. Research results with FMADM SAW method had the value of accuracy which suits the students' interest as much as 60%, whereas the accuracy obtained in accordance with the reality of majors is as much as 90%.**

Keywords— **FMADM, SAW, Major Selection**

I. INTRODUCTION

The major selection of senior high school students is determined on the basis of academic ability as well as the factors of students' interest. The student's interest is considered important in the process of major selection because the student will feel pleased when studying. In addition major selection adjusted against interest will positively influence in the academic achievement. Thus, in senior high school, major selection is not the problem of intelligence but the problem of students' interest and aptitude [1].

The early brainstorming for major selection can ease the students to choose the field of study that will be learned in the Academy or University which certainly will lead to his career in the future. The current curriculum used at high school, the major selection is carried out in the beginning of class X. The major selection of high school students is one effort to steer students based on academic ability and students' interest. In addition, the process of major selection involves several criteria which are used as the consideration, i.e. the value of students' academic, the results of psychological test and the questionnaire of students' interest. Educational units can add the criteria major selection

according to the characteristics and needs of each educational unit [2].

The system of major selection has been used by the teachers is still done manually. Teachers have to select one by one in determining the major to each student based on the value of student's academic, the value of student's placement test and the questionnaire of student's interest, therefore, the process of major selection of the student takes quite a long time to get the results of the major selection.

The model used in the system of decision support is Fuzzy Multiple Attribute Decision Making (FMADM) by Simple Additive Weighting (SAW) method. SAW method is selected for this decision support system because this method determines weights for each attribute, then it is followed by ranking process that will select the best alternative from a number of alternatives. The preferred alternative is the students who will take the major of science or social science. This method is expected to get a more accurate result because it is based on the value of criteria and determined weighting.

Some researchers have been performed in applying FMADM techniques, such as selection of managers on the company which is engaged in the development of MAPNA oil, gas and other industries, the researcher used Fuzzy SAW method as the solution to solve the problem [3]. Widayanti [4] in his study of the analysis and implementation of Fuzzy multiple-Attribute Decision Making method selected the students who have good achievement by using Simple Additive Weighting (SAW). FMADM technique using SAW method is applied as decision support to determine the students who are worthy to receive a scholarship at SMAN 2 Semarang [5]. Applying FMADM techniques is as decision support to rank the service of website [6].

Therefore, to optimize the process of major selection in accordance with a curriculum based on the interests and desires of the students at senior high school is required the research and development of system of decision support in order to determine the major based on the interest of students. This system will be a tool to support decision for the stakeholders who are related to the students' academic data, choose the major selection which is suitable to the interests and desire which combined with the academic value, parents' desire and based on the value of the placement test.

II. OVERVIEW

A. Senior High School Major Selection

The major selection of high school students is one effort to steer students based on academic ability and interest of students including the sciences (IPA), social sciences (IPS), and Linguistics [2]. It will be suitable to the students' interests and abilities. The purpose is, in the future, to make the subject given to the students more focused because it has been accordance with the students' interest. Furthermore, in doing the proper major selection can provide benefits such as grouping students according to their proficiencies, abilities, talents, and interests which are relatively the same, helping students prepare to continue their studies and choose the world of work, and helping them strengthen the success and the continuation of study and the world of work. The process of major selection involves several criteria which are used as the consideration, i.e. the value of students' academic, the result of psychological test and the questionnaire of students' interest. Educational units can add the criteria of major selection in according to the characteristics and the needs of each educational unit.

B. Decision Support System

Decision Support System (DSS) is a specific information system which is intended to assist management in making a decision with regard to the question of which semi structured, and it does not replace the function of the decision makers in making informed decisions. Decision support system combines the intellectual resource of individuals with computer capabilities to improve the quality of the decisions. Some components in the DSS include [7] :
a. Subsystem data management
b. Subsystem model management
c. Subsystem user interface
d. Subsystem knowledge-based management

C. Fuzzy Multi Attribute Decision Making (FMADM)

Fuzzy Multi-Attribute Decision Making is a method used to find the optimal alternative from a number of alternatives for certain criteria. FMADM is the core from determining the value of the weights for each attribute, followed by a ranking process that will select the alternative that has been given. Basically, there are three approaches to find the weights of attributes, namely the approaches of subjective and objective and the approach of integration between the subjective and objective. Each approach has advantages and disadvantages. In the subjective approach, the weights are determined based on the subjectivity of decision makers, so that some of the factors in the alternative ranking can be determined independently. While the objective approach, the weights are mathematically calculated that ignore the subjectivity of the decision makers [8].

There are several methods that can be used to solve the problems of FMADM namely [8]:
a. Simple Additive Weighting (SAW)
b. Weighted Product (WP)
c. ELECTRE
d. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
e. Analytic Hierarchy Process (AHP)

D. Simple Additive Weighting (SAW)

The SAW method is probably the best known and widely used for multiple attribute decision making MADM. Because of its simplicity, SAW is the most popular method in solving MADM problems [4].

SAW method is often known as the term of weighted summation method as well. The basic concept of SAW method is to find a weighted sum of performance rating on each alternative in all attributes. SAW method requires a process of decision matrix normalizing (X) to a scale that can be compared with all the rating of the alternatives. To calculate the attribute of benefit, it is used the formula as in Equation 1.

$$r_{ij} = \frac{x_{ij}}{Max\ x_{ij}} \quad (1)$$

To calculate the attribute of cost, it is used the formula as in Equation 2.

$$r_{ij} = \frac{Min\ x_{ij}}{x_{ij}} \quad (2)$$

with:

r_{ij} : The normalized performance rating of alternative A_i on attribute C_j

i : 1,2,3,….m

j : 1,2,3,…..n

$Max\ x_{ij}$: maximum value of each row and column

$Min\ x_{ij}$: minimum value of each row and column

x_{ij} : rows and columns of a matrix

To calculate the value of the preference for each alternative, it is used the formulas in Equation 3

$$V_i = \sum_{j=1}^{n} w_j\ r_{ij} \quad (3)$$

with:

V_i : end value of the alternative

w_{ij} : the specified weights

r_{ij} : matrix normalization

This research uses FMADM SAW method. The steps are:

Step 1: Determining the criteria that will be used as a reference in decision-making, namely Ci.

Step 2: Determining the suitability rating of each alternative on each criterion.

Step 3: Making decisions based on criteria matrix (Ci).

Step 4: Normalizing matrix based on the adapted equation with the type of benefit attribute (attribute or cost attribute) so that it is obtained normalized matrix R.

Step 5: The final results are obtained from the ranking process, namely, the sum of normalized matrix R with the weight vector in order to obtain the greatest value which is selected as the best alternative (Ai) as the solution.

III. METHODOLOGY

Research on flowchart shown in Figure 1, the first stage, it was the study of the literature related to the research. The second stage, it determined the criteria that would be used as reference in major selection. The criteria included the value of report, the value of UN, the value of US, the value of the placement test, and the questionnaire of students' interests. The next stages, it determined the conformity assessment of every alternative at each criterion based on FMADM. Preference weights and calculation of decision matrix and forming the normalized matrix (R) were based on the attributes of Max benefit, the maximum value of each row and column so that it was obtained the normalized matrix (R). The ranking process of the normalized matrix (R) was to obtain the biggest value that would be the best option.
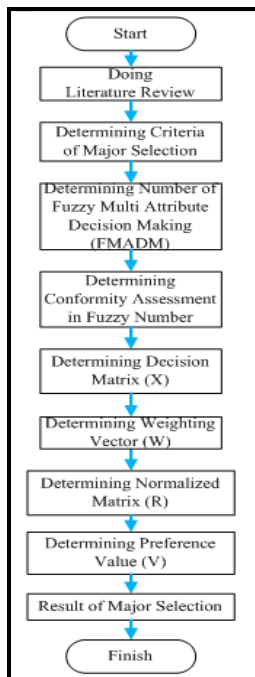

Figure 1. Research Flow

IV. RESULT

A. Determining Criteria

In the research method, there are weights and needed criteria to determine the students who will enter class IPA or IPS. The criteria used in the major selection for senior high school students such as Table I.

TABLE I
DETERMINING CRITERIA

Criteria	
C1	UN Value
C2	*Placement Test Value*
C3	US Value

C4	Report Value
C5	Questionnaire

The first criterion which is considered in the major selection is the value of national examination (UN). In this criteria, the value of UN is made on the range of value based on policy which is then converted to fuzzy numbers as in Tabel2.

TABLE II
FUZZY NUMBERS FOR UN VALUE

Limit of UN value (C1)	Variable	Fuzzy Numbers
0-54	Very Poor (VP)	0
55-60	Poor (P)	0.25
61-70	Fair (F)	0.5
71-85	Good (G)	0.75
86-100	Very Good (VG)	1

The second criterion in the major selection for senior high school students is considering the value of the placement test, then the value is converted to fuzzy numbers as shown in Table III.

TABLE III
FUZZY NUMBERS FOR PLACEMENT TEST VALUE

Limit of *Placement Test* (C2)	Variable	Fuzzy Numbers
0-50	Poor (P)	0
51-70	Fair (F)	0.5
71-100	Good (G)	1

The value of School Exams (US) is the criterion that needs to be considered in the major selection. The range of values of the US has been determined with converted fuzzy numbers as in Table IV.

TABLE IV
FUZZY NUMBERS FOR US VALUE

Limit of US value(C3)	Variable	Fuzzy Numbers
0-54	Very Poor (VP)	0
55-60	Poor (P)	0.25
61-70	Fair (F)	0.5
71-85	Good (G)	0.75
86-100	Very Good (VG)	1

The fifth criterion, which it is considered in the major selection, is the average of the report value. Based on the existing values, it is converted with fuzzy numbers as in Table V.

Limit of Report Value (C4)	Variable	Fuzzy Numbers
0-60	Very Poor (VP)	0
61-79	Poor (P)	0.25
80-84	Fair (F)	0.5
85-95	Good (G)	0.75
96-100	Very Good (VG)	1

The last criterion which is used in the major selection is the questionnaire of the students' interest. From that questionnaire will be converted with fuzzy numbers as in Table VI.

TABLE VI
FUZZY NUMBERS FOR STUDENT INTEREST

Questionnaire of Student (C5)	Variable	Fuzzy Numbers
1	IPA	1
2	IPS	0.5

B. The Result of Major Selection

The process of major selection of students at senior high school uses 10 data samples from 40 data that have been tested, by entering alternatives and criteria. Alternatives which are included are senior high school students, while the criteria which are included are the value of national examination, the value of the placement test, the value of school examination, the value of report and the questionnaire of students' interest.

TABLE VII
SAMPLING DATA

Student	C1	C2	C3	C4	C5
Student 1	8.55	73.11	86.5	84	1
Student 2	7.13	72.33	80.5	83.83	2
Student 3	8.53	66.56	82.5	81.17	1
Student 4	8.47	70.44	79.5	82.17	1
Student 5	7.4	72.89	81.5	80.83	2
Student 6	7.52	63.33	80.5	81	2
Student 7	6.05	43.44	82	79.5	1
Student 8	6.74	41.89	84.5	81	1
Student 9	8.42	50.22	81.5	79.5	2
Student 10	6.07	44.33	80	79.17	2

From the student sample data in Table VII, the next stage is to determine the conformity assessment of each alternative to fuzzy numbers which are determined specified against each criterion. The conformity assessment stages as shown in Table VIII.

TABLE VIII
CONFORMITY ASSESSMENT FMADM

Student	C1	C2	C3	C4	C5
Student 1	0.75	1	1	0.5	0.6
Student 2	0.75	1	0.75	0.5	0.4
Student 3	0.75	0.5	0.75	0.5	0.6
Student 4	0.75	0.5	0.75	0.5	0.6
Student 5	0.75	1	0.75	0.5	0.4
Student 6	0.75	0.5	0.75	0.5	0.4
Student 7	0.25	0	0.75	0.25	0.6
Student 8	0.5	0	0.75	0.5	0.6
Student 9	0.75	0	0.75	0.25	0.4
Student 10	0.25	0	0.75	0.25	0.4

After determining the conformity assessment of each alternative to fuzzy numbers which are determined against each criterion, the next stage is to determine decision matrix (X):

$$
X = \begin{bmatrix}
0.75 & 1 & 1 & 0.5 & 0.6 \\
0.75 & 1 & 0.75 & 0.5 & 0.4 \\
0.75 & 0.5 & 0.75 & 0.5 & 0.6 \\
0.75 & 0.5 & 0.75 & 0.5 & 0.6 \\
0.75 & 1 & 0.75 & 0.5 & 0.4 \\
0.75 & 0.5 & 0.75 & 0.5 & 0.4 \\
0.25 & 0 & 0.75 & 0.25 & 0.6 \\
0.5 & 0 & 0.75 & 0.5 & 0.6 \\
0.75 & 0 & 0.75 & 0.25 & 0.4 \\
0.25 & 0 & 0.75 & 0.25 & 0.4
\end{bmatrix}
$$

Decision matrix (X) which have been determined, the next stages is to determine normalized matrix (R) by using the formula of Equation (1). The example of the normalization calculation of the decision matrix (X):

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

The results of the normalization calculations are obtained normalized matrix (R):

$$
R = \begin{bmatrix}
1 & 1 & 1 & 1 & 1 \\
1 & 1 & 0.75 & 1 & 0.67 \\
1 & 0.5 & 0.75 & 1 & 1 \\
1 & 0.5 & 0.75 & 1 & 1 \\
1 & 1 & 0.75 & 1 & 0.67 \\
1 & 0.5 & 0.75 & 1 & 0.67 \\
0.33 & 0 & 0.75 & 0.5 & 1 \\
0.67 & 0 & 0.75 & 1 & 1 \\
1 & 0 & 0.75 & 0.5 & 0.67 \\
0.33 & 0 & 0.75 & 0.5 & 0.67
\end{bmatrix}
$$

The final step in major selection of senior high school students using the FMADM technique with the method of SAW is to determine ranking or the value of the preference of each alternative. The value of preferences can be calculated by using the formula of Equation (3) i.e. by summing the results of the multiplication between the normalized matrix (R) and the weighting vector (W). The Specified weighting vector W = [30 30 10 10 20]. The following example is the calculation to determine the value of preference:

$$v1 = (1)(30) + (1)(30) + (1)(10) + (1)(10) + (1)(20) = 100$$

Based on calculation the value of preferences or ranking, it is obtained the final results of each alternative as in Table IX.

TABLE IX
RESULT ASSESSMENT

Student	Score
Student 1	100
Student 2	90.83
Student 3	82.5
Student 4	82.5
Student 5	90.83
Student 6	75.83
Student 7	42.5
Student 8	57.5
Student 9	55.83
Student 10	35.83

C. Validity Test

Based on the results of the preference value which is resulted for each alternative (Vi) by summing the results of the multiplication between the normalized matrix (R) and the weighting vector (W). The next process is determining the major selection of each alternative. To determine the major selection of IPA or IPS, the decision makers have already determined the range value. Students who get the final value more than or equal 60 will be geared at Sciences (IPA), while for students who earn less than 60 will lead on Social Sciences (IPS).

The results of major selection using the technique of FMADM with the method of SAW, based on the students' interests, have conformity as many as 24 data from 40 tested samples, therefore, the value of accuracy is as much as 60%. While based on the reality of major selection, it matches as many as 36 data from 40 tested data samples, so the value of accuracy is as much as 90%.

V. CONCLUSION

The research that has been done using the technique of Fuzzy Multi Attribute Decision Making (FMADM) it can be concluded that the technique of the FMADM with SAW method could be used in the process of major selection for senior high school. Although it uses a simple weighting calculation, this method could give the best results in the process of calculation. The research results with the technique of FMADM SAW method had the value of accuracy with the students' interest as much as 60%, whereas, the reality accuracy gets as much as 90%.

REFERENCES

[1] Departemen Pendidikan Nasional (2006), *Panduan Penyusunan Laporan Hasil Belajar Peserta Didik Sekolah Menengah Atas (SMA)*, Direktorat Jenderal Manajemen Pendidikan Dasar Dan Menengah Direktorat Pembinaan SMA, Jakarta 2006 .

[2] Departemen Pendidikan Nasional (2004), *Panduan Penilaian Penjurusan Kenaikan Kelas dan Pindah Sekolah*, Direktorat Pendidikan Menengah Umum, Jakarta 2004 . [3] A. R. Afshari, R. Yusuff, and A. R. Derayatifar, "Project manager selection by using fuzzy simple additive weighting method," *ICIMTR 2012 - 2012 Int. Conf. Innov. Manag. Technol. Res.*, pp. 412–416, 2012.

[3] A. R. Afshari, R. Yusuff, and A. R. Derayatifar, "Project manager selection by using fuzzy simple additive weighting method," *ICIMTR 2012 - 2012 Int. Conf. Innov. Manag. Technol. Res.*, pp. 412–416, 2012.

[4] W. Deni, O. Sudana, and A. Sasmita, "Analysis and Implementation Fuzzy Multi-Attribute Decision Making SAW Method for Selection of High Achieving Students in Faculty Level," *Int. J. Comput. Sci. Issues*, vol. 10, no. 1, pp. 674–680, 2013.

[5] K. Kunci, S. Pendukung, W. Engineering, and L. Belakang, "Sistem Pendukung Keputusan Beasiswa Berbasis Web Pada Sma Negeri 2 Semarang Menggunakan Metode Fuzzy Multiple Attribute Decission 2 . 2 Metode Fuzzy Multiple Attribute Decission Making (FMADM) dan Metode Simple Additive Weighting 2 . 3 Jenis Beasiswa Se," pp. 1–6, 2009.

[6] R. Mohanty, V. Ravi, and M. R. Patra, "Application of fuzzy multi attribute decision making analysis to rank web services," *2010 Int. Conf. Comput. Inf. Syst. Ind. Manag. Appl. CISIM 2010*, no. i, pp. 398–403, 2010.

[7] M. Kusrini, "Kom. Konsep dan Aplikasi Sistem Pendukung Keputusan," *Penerbit ANDI, Yogyakarta, Ed.*, vol. 1, 2007.

[8] S. Kusumadewi, S. Hartati, A. Harjoko, and R. Wardoyo, "Fuzzy Multi-Attribute Decision Making (FUZZY MADM)," *Yogyakarta Graha Ilmu*, 2006.