



Implementation of analytical hierarchy process and simple additive weighting for major selection

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ABSTRACT

A decision support system is a system that can quickly solve problems that occur in rankings and can find out the highest to lowest values in an election. This study aims to implement the Analytical Hierarchy Process and Simple Additive Weighting methods in analyzing data on criteria and decision alternatives that can be used by prospective students who are still unsure about which major to take in college. The criteria used in this study were suitability with educational background, semester fees, employment, interests and talents and parents' requests. while the alternatives used are all faculties and study programs at Budi Luhur University. The analysis was carried out using the Analytical Hierarchy Process method to determine the weight of the criteria used and the Simple Additive Weight method to find out the ranking of non-uniform assessments to determine the priority of alternative choices. The results of the analysis using the two methods are that the engineering faculty is ranked 1 (one), meaning that the best choice for majors based on the criteria compiled is the engineering faculty with a choice of two majors, namely architecture and electrical engineering.

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1. INTRODUCTION

Information technology includes all matters relating to the process, use as a tool, manipulation, and management of information (Huda, 2020). Technological developments cannot be avoided in everyday life (Aslamiyah & Agustina, 2021). One of the uses of technology in everyday life is the use of decision support systems as a tool that can be used to assist in decision making. A decision support system is a system that can solve problems that occur in ranking quickly and can find out the highest to lowest values in a selection (Manurung, 2018). Another opinion was expressed by Lestari & Savitri Puspaningrum (2021) related to the definition of a decision support system. Decision Support System is a system intended to support managerial decision makers in semi-structured decision situations (Lestari & Savitri Puspaningrum, 2021). The Decision Support System (DSS) was first introduced by Gorry and Scott Morton in 1971 to provide decision makers with a number of considerations to assist them in making decision (Liawan, 2019).

The suggestions generated by the decision support system are not used as an absolute determinant of decision making but can be a consideration for the decision maker in making a decision. The problem in making decisions without using a decision support system is the tendency that the decisions taken are objective by relying on the personal opinion and personal judgment of the decision maker without being accompanied by clear data analysis.

In accordance with the applicable curriculum in Indonesia, prospective students who will continue their higher education must face the choice of majors (Rahmayu & Serli, 2019). For this reason, prospective students are expected to be able to assess their interests, talents and abilities so they don't choose the wrong major to take. Selection of majors is the beginning of career selection in the future. Sometimes many prospective students choose majors because of the influence of friends. The role of parents is very important. Parents should be able to direct their children to choose majors according to their interests, talents and abilities. This study aims to manage criteria and alternative data in selecting majors in order to produce output in the form of suggestions for selecting majors. The method used in this study is the Analytical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods. The reason for using AHP is because AHP Takes into account the validity up to the inconsistency tolerance limit as the criteria and alternatives chosen by the decision maker (Saputra & Nugraha, 2020). The reason for choosing SAW is because the basic concept of the SAW (Simple Additive Weighting) method is to find the weighted sum of the performance ratings for each alternative on all attributes (Narti, 2021).

2. RESEARCH METHOD

The stages used in the development of this decision support system are as shown in Figure 1 below.

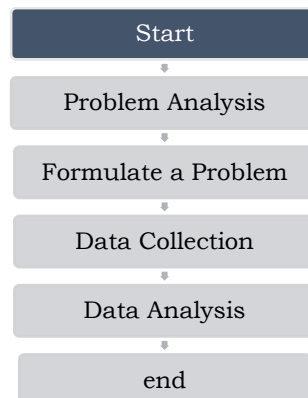


Figure 1. Research Stage

The way the AHP method works is by completing the criteria weight matrix at the beginning, then continuing on to the alternatives (Nurajizah et al., 2020). The Analytical Hierarchy Process (AHP) method has 3 (three) working principles, namely hierarchical arrangement, priority setting, and logical consistency. The explanation of the working principles of the Analytical Hierarchy Process (AHP) method, namely:

- a. Decomposition, is the process of solving or dividing a complete problem into elements by compiling a hierarchy by identifying the knowledge or information being observed starting from a complex problem which is broken down into its main elements which are further broken down into its parts again so that it is more hierarchical. The hierarchy of issues from this evaluation is explained in Figure 2 (Septilia & Styawati, 2020).

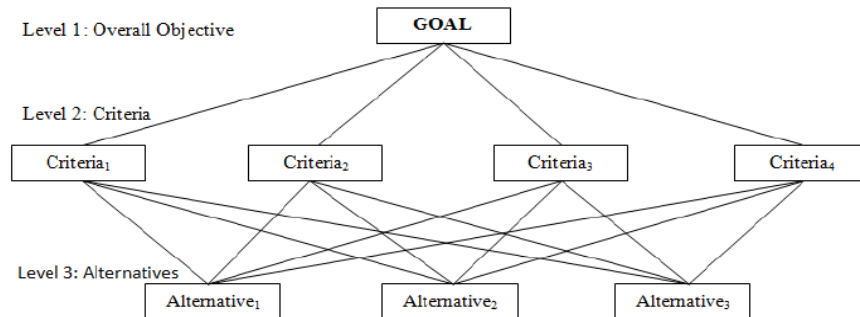


Figure 2. AHP Hierarchical Structure

- b. Comparative Judgement, is an assessment made based on the relative importance of two elements at a certain level in relation to the level above it. Scale 1 – 9 is set as a consideration (Dzulhaq et al., 2019). Values and definitions of qualitative opinions from the Saaty comparison scale which can be seen in table 1.

Table 1. The Saaty Pairwise Comparison Scale

Score	Description
1	Vertical factors are just as important as horizontal factors
3	Vertical factors are more equally important than horizontal factors
5	The vertical factor is clearly more important than the horizontal factor
7	The vertical factor is clearly more important than the horizontal factor
9	The absolute vertical factor is more important than the horizontal factor
2, 4, 6, 8	When in doubt between two adjacent element values
1/(2-9)	The opposite of the statement value 2 – 9

- 1) Synthesis of priority (determining priority), namely using the eigen vector method to obtain relative weights for the elements of decision making.
- 2) Logical Consistency. Means that all elements are logically grouped and consistently ranked according to a logical criterion.

When solving a problem, we must first know the steps of the AHP method used.

The following are the steps in solving a problem with the AHP method, namely:

- a. Set priorities. In setting priorities, it is done by compiling pairwise comparisons. If there are n operating subsystems, then the operating elements are A₁, A₂, , A_n. Then the results of the comparison of the elements of the operation will form an n x n matrix A as follows (Noviyanti, 2019):

Table 2. Pairwise Comparison Matrix

	A ₁	A ₂	...	A _n
A ₁	a ₁₁	a ₁₂	...	a _{1n}
A ₂	a ₂₁	a ₂₂	...	a _{2n}
⋮	⋮	⋮	⋮	⋮
A _n	a _{n1}	a _{n2}	...	a _{nn}

The A_n x n matrix is a reciprocal matrix, which assumes that there are n elements, namely W₁, W₂,, W_n which form the comparison. The pairwise comparison values between w_i, w_j are represented in a matrix w_i, w_j = a_{ij} with ij = 1, 2, 3, ... n while the a_{ij} value is the matrix value resulting from the comparison which reflects the value of A_i's interest in the A_j concerned so that a matrix is obtained which is normalized. The value of a_{ij}= , for i = j (the diagonal of the

matrix has a value of 1), or if the operational elements A_i and A_j have the same level of importance then the value of $a_{ij} = a_{ji} = 1$. If the weighting vector of the operating elements is expressed by W , by $W = (w_1, w_2, \dots, w_n)$, then the intensity of the importance of the elements of operation A_1 to A_2 is $\frac{1}{2} = 12$, so that the pairwise comparison matrix can be seen in table 3 (Riris Immasari et al., 2019).

Table 3. Operational Elements Interest Intensity Comparison Matrix

	A_1	A_2	...	A_n
A_1	$\frac{w_1}{w_1}$	$\frac{w_1}{w_2}$...	$\frac{w_1}{w_n}$
A_2	$\frac{w_2}{w_1}$	$\frac{w_2}{w_2}$...	$\frac{w_2}{w_n}$
\vdots	\vdots	\vdots	\ddots	\vdots
A_n	$\frac{w_n}{w_1}$	$\frac{w_n}{w_2}$...	$\frac{w_n}{w_n}$

Based on the pairwise comparison matrix, normalization is carried out with the following steps:

- 1) The weight of each column j is summed up, the total value of the column is denoted by S_{ij} .

$$S_{ij} = \sum_{i=1}^n a_{ij} \quad (1)$$

- 2) The value of each column is divided by the total value of the column. The result of the division is denoted by V_{ij}

$$V_{ij} = \frac{w_j}{w_1}; ij = 1, 2, 3, \dots, n \quad (2)$$

- 3) Next, by calculating the relative priority vector of each criterion by averaging the weights that have been normalized with the i -th row denoted by P_i .

$$P_i = \sum_{i=1}^n \quad (3)$$

- b. Determine the eigenvalue and eigenvector. The following is a definition of eigenvalue and eigenvector, namely:

- 1) Matrix. Is a rectangular arrangement of elements – elements (numbers) that consist of several rows and columns and are delimited by a minus sign, as follows:

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{m1} & a_{m2} & a_{m3} & \dots & a_{mn} \end{pmatrix} \quad (4)$$

- 2) Vectors and Dimensions. Mathematically, a vector is determined by its vector ends which are expressed by real numbers (a, b) in space two. In general, this definition can be expanded in space n , (n positive numbers) or R_n .

- 3) Eigen values and Eigen vectors. To determine the value of each on the $m \times n$ matrix then; the total value of the matrix in each column is compared with the value of the matrix and summed up for each row. If A is an $m \times n$ matrix, then the nonzero vector x inside is called an eigen vector of A if Ax is a scalar multiple of x ; that is, for a scalar is called the eigen value of A and x is said to be the corresponding eigenvector. To find the eigen values of an $n \times n$ matrix A , we rewrite $Ax = \lambda x$ as Ax equals or equivalently.

$$\det(\lambda I - A) = 0 \quad (5)$$

so that it becomes an eigenvalue then there must be a non-zero solution called characteristic A; the scalar that satisfies this equation is the value of eigen A.

- 4) Geometric Interpretation. Is a vector = non-zero vector that satisfies this equation is called an eigenvector of T associated with λ . If λ is the eigenvalue of A, and x is a related eigenvector then $Ax = \lambda x$, so the product A maps into a scalar product with itself. In R2 and R3, this means that product A maps x each eigenvector x to a vector that lies on the same line as x. If it is known that the ratio of elements A_i to A_j is then theoretically the matrix has the opposite positive characteristic, namely $a_{ij} = 1$. The weight sought is expressed in vector = (1, 2, 3,...n). the value represents the weight of the criteria A_n to the entire set of criteria in that subsystem. If a_{ij} represents the degree of importance of factor i to factor j and a_{ik} represents the degree of importance of factor j to factor k. For a matrix consistent with vector w, the elements can be written:

$$V_{ij} = \frac{w_j^2}{w_i^2}; ij = 1,2,3, \dots n \quad (5)$$

So, the consistency matrix is :

$$a_{ij} = \frac{w_i}{w_j}, \frac{w_j}{w_k}, \frac{w_i}{w_k} = a_{ik} \quad (6)$$

As described above, then for pairwise comparison matrix is decomposed into:

$$a_{ij} = \frac{w_i}{w_j}, \frac{1}{w_j/w_j} = \frac{1}{a_{ij}} \quad a_{ij} \cdot \frac{w_i}{w_j} = 1 \quad (7)$$

From these equations it can be seen that:

$$(\lambda I - A)x = 0 \quad (8)$$

Thus for a consistent pairwise comparison matrix it becomes:

$$\sum_{i,j=1}^n a_{ij} \cdot w_{ij} \cdot \frac{1}{w_{ij}} = n; A_{ij} = 1,2,3, \dots n \quad (9)$$

$$\sum_{i,j=1}^n a_{ij} \cdot w_{ij} = n w_{ij}; A_{ij} = 1,2,3, \dots n \quad (10)$$

This equation is equivalent to the form of the matrix equation below:

$$A \cdot w = n \cdot w \quad (11)$$

In matrix theory, this formulation is expressed that w is an eigenvector of matrix A with an eigenvalue of n. Please note that n is the dimension of the matrix itself. In the form of a matrix equation can be written as follows:

$$\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad (12)$$

But in practice it cannot be guaranteed that:

$$a_{ij} = \frac{w_{ik}}{w_{jk}} \quad (13)$$

One reason is because the human element (decision maker) cannot always be absolutely consistent in expressing preferences for the elements being

compared. In other words, that the assessment given to each element of the problem at a hierarchical level may be inconsistent.

5) Calculating the Consistency Index.

Indicators of consistency are measured through the consistency index as follows (Umar et al., 2018):

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (14)$$

Description :

CI = Consistency index deviation ratio

λ_{\max} = The largest eigenvalue of an ordered matrix

n = Matrix order

If the CI value is zero, then the pairwise comparison matrix is consistent. The inconsistency limit set by Thomas L. Saaty is determined using the Consistency Ratio (CR), which is a comparison of the consistency index with a random index (RI) or random index (IR) value, which can be formulated as follows (Azhar, 2019):

$$CR = \frac{CI}{RI} \quad (15)$$

Description :

N = The number of criteria

CR = Consistency Ratio

RI = Index Random

Random index values can be obtained from table 2

Table 4. Random Index Value

N	1	2	3	4	5	6	7	8	9	10
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,48

Source : Saaty, T. Lorie. 1993 [15]

AHP measures the overall consistency of the assessment using a consistency ratio (CR) at a certain level of consistency required in prioritizing to obtain the best results. The value of $CR \leq 0.100$ is consistent, otherwise it needs to be revised again.

3. RESULTS AND DISCUSSIONS

3.1 Criteria Identification

The criteria are used for ranking alternative majors, the criteria are compiled based on observations and pre-research interviews with several prospective students. The list of criteria used in this study can be seen in table 5 below.

Table 5. Criteria

No.	Criteria	Code
1	Appropriate educational background	C1
2	Semester fees	C2
3	Availability of jobs	C3
4	Interest and talent	C4
5	parent orders	C5

3.2 Alternatif

The alternatives used in this research are all faculties and study programs at Budi Luhur University. An alternative explanation can be seen in table 6.

Table 6. List of Alternatif

No.	Code	Faculty	Majors
1	A1	Faculty of Information Technology	Technical Information Information Systems Computer system
2	A2	faculty of Economics and Business	Accountancy Management Disaster Management
3	A3	Faculty of Engineering	Electro Architecture
4	A4	Faculty of Social Science and Political Science	International Relations Criminology
5	A5	Faculty of Communication and creative design	Communication Studies Visual communication design

Linkages Between Criteria and Alternatives

Table 7. Relationship Between Criteria and Alternatives

No.	Faculty	Majors	C1	C2	C3	C4	C5
1	Faculty of Information Technology	a Technical Information	5,2	30	0	6	2
		b Information Systems	7,3	25	0	5	1
		c Computer system	3,5	35	0	5	1
2	Faculty of Economics and Business	a Accountancy	5,6	25	0	1	1
		b Management	10,4	35	0	1	1
		c Disaster Management	10,7	35	0	2	3
3	Faculty of Engineering	a Electro	1,2	30	0	1	1
		b Architecture	3,1	15	0	2	1
4	Faculty of Social Science and Political Science	a International Relations	13,9	32	0	1	1
		b Criminology	38,2	40	0	1	2
5	Faculty of Communication and creative design	a Communication Studies	17,4	30	0	1	1
		b Visual communication design	29,3	50	0	1	1

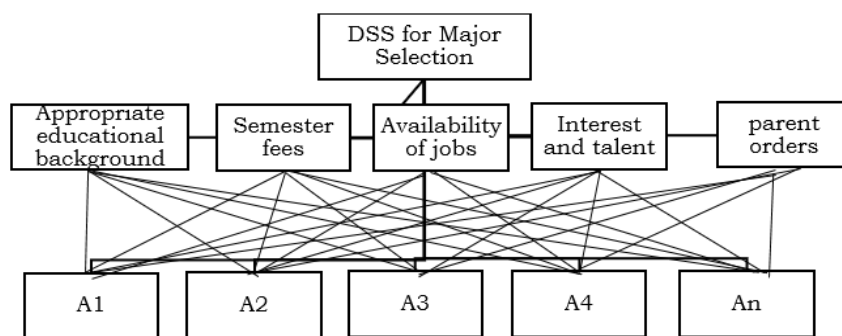


Figure 3. AHP Hierarchy

Figure 3 explains that the goal of this research is to determine the majors. There are five criteria in the hierarchical structure image. Meanwhile, the alternatives are described from A1 to A5.

3.3 Calculate the AHP Method Criteria

The AHP calculation process is carried out to obtain priority weight values from the existing criteria. The following are the steps taken in the AHP calculation process:

a. Pairwise Comparison

At this stage a comparative assessment is carried out between one criterion and another, where the data is obtained from a questionnaire as in the attachment and the assessment results are obtained from interviews with respondents .

Table 8. Pairwise Comparison

Criteria	C1	C2	C3	C4	C5
C1	1/1	3/1	2/1	2/1	2/1
C2	1/3	1/1	2/1	2/1	2/1
C3	1/2	1/2	1/1	2/1	2/1
C4	1/2	1/2	1/2	1/1	2/1
C5	1/2	1/2	1/2	1/2	1/1

b. Normalization of Criteria Value Matrix.

The normalization matrix is obtained by dividing the comparison value of each criterion with the total results which can be seen in table 9.

Table 9. Matrix Normalization Comparison of Criteria

Major Selection	C1	C2	C3	C4	C5	Total
C1	0,35	0,55	0,33	0,27	0,22	1,72
C2	0,12	0,18	0,33	0,27	0,22	1,12
C3	0,18	0,09	0,17	0,27	0,22	0,92
C4	0,18	0,09	0,08	0,13	0,22	0,71
C5	0,18	0,09	0,08	0,07	0,11	0,53
Total	1,00	1,00	1,00	1,00	1,00	5,00

c. Determine the Priority Criteria Value

The priority of the criteria is the average value of the criteria which can be calculated by dividing the total value of the comparison matrix for each criterion by the number of criteria, which is in table 10.

Table 10. Criteria Priority Value

No.	Criteria	Total	Priority Value
1	Appropriate educational background	1.72	0.34
2	Semester fees	1.12	0.22
3	Availability of jobs	0.92	0.18
4	Interest and talent	0.71	0.14
5	parent orders	0.53	0.11

d. Calculating the Consistency Ratio Value

This stage is carried out to find out whether the criteria comparison assessment is consistent or not. The following steps are taken to get the consistency ratio as follows:

- 1) Create a Row Addition Matrix. This matrix is made by multiplying the pairwise comparison matrices in table 9. with priority values in table 10. The calculation results can be seen in table 11.

Table 11. The Addition Matrix for Each Row

Major Selection	C1	C2	C3	C4	C5	Jumlah
C1	0,34	0,67	0,37	0,28	0,21	1,88
C2	0,11	0,22	0,37	0,28	0,21	1,20
C3	0,17	0,11	0,18	0,28	0,21	0,96
C4	0,17	0,11	0,09	0,14	0,21	0,73
C5	0,17	0,11	0,09	0,07	0,11	0,55

- 2) Calculate the consistency vector by determining the average value of Weighted Sum Vector.

$$\begin{aligned}
 1,88 & : 0,34 = 5,46 \\
 1,20 & : 0,22 = 5,36 \\
 0,96 & : 0,18 = 5,22 \\
 0,73 & : 0,14 = 5,16 \\
 0,55 & : 0,11 = 5,23
 \end{aligned}$$

- 3) Calculating the average value of the consistency vector is as follows:

$$\lambda = \frac{(5,46 + 5,36 + 5,22 + 5,16 + 5,23)}{5} = 5,29$$

- 4) Calculating the Consistency Index

$$CI = \frac{\lambda_{\max} - n}{n - 1}, n : \text{Ordo matriks}$$

$$CI = \frac{5,29 - 5}{5 - 1}$$

$$CI = \frac{0,29}{4}$$

$$CI = 0,07$$

- 5) Calculating the Consistency Ratio (CR)

The CR value is calculated by dividing the CI value by the IR value (CI/RI).

$$CR = CI/RI$$

Because the number of location determination criteria used is 5 (five), the IR value is 1.12, so:

$$CR = CI/RI$$

$$CR = 0,07 / 1,12$$

$$CR = 0,06$$

CR value < 0.1, means that the criteria weighting preference is consistent or acceptable.

- e. Ranking Determination of Promotional Locations With SAW

After obtaining the weight value of each criterion and conducting the Consistency Ratio (CR) test, the next step is to determine the ranking using the Simple Additive Weighting (SAW) method. The process of determining the ranking of the SAW method is as follows:

- 1) Determine Benefit and Cost Functions

Table 12. Determine Benefit and Cost Functions

No.	Criteria	function
1	Appropriate educational background	Benefit
2	Semester fees	Cost
3	Availability of jobs	Benefit
4	Interest and talent	Benefit
5	parent orders	Benefit

- 2) After knowing the benefit function (+) and cost function (-) of each criterion as shown in table 4.12, Table 4.13 explains the value matrix of alternative decision support systems.

Table 13. Determination Alternative Value Matrix

Alternatif	Major	C1	C2	C3	C4	C5
Faculty of Information Technology	Technical Information	5,2	30	0	6	2
	Information Systems	7,3	25	0	5	1
Faculty of Economics and Business	Computer system	3,5	35	0	5	1
	Accountancy	5,6	25	0	1	1
	Management	10,4	35	0	1	1
Faculty of Engineering	Disaster Management	10,7	35	0	2	3
	Electro	1,2	30	0	1	1
	Architecture	3,1	15	0	2	1

Faculty of Social Science and Political Science	International Relations	13,9	32	0	1	1
Faculty of Communication and creative design	Criminology	38,2	40	0	1	2
	Communication Studies	17,4	30	0	1	1
	Visual communication design	29,3	50	0	1	1
weight		0,34	0,22	0,18	0,14	0,11

Table 14 explains the final normalization of the total scores and rankings obtained to find out which study program has priority to be chosen when continuing to university level.

Table 14. Final Matrix Normalization

Alternatif (Faculty)	Major	C1	C2	C3	C4	C5	Tota 1	Avg	Rank
Information Technology	Technical Information	0,20	0,13	0,00	0,09	0,07	0,50	0,16	2
	Information Systems	0,14	0,11	0,00	0,08	0,04	0,37		
	Computer system	0,30	0,15	0,00	0,08	0,04	0,57		
Economics and Business	Accountancy	0,19	0,11	0,00	0,02	0,04	0,35	0,12	3
	Management	0,10	0,15	0,00	0,02	0,04	0,31		
	Disaster Management	0,10	0,15	0,00	0,03	0,11	0,39		
Engineering	Electro	0,88	0,13	0,00	0,02	0,04	1,06	0,59	1
	Architecture	0,34	0,07	0,00	0,03	0,04	0,47		
Social Science and Political Science	International Relations	0,08	0,14	0,00	0,02	0,04	0,27	0,095	4
	Criminology	0,03	0,18	0,00	0,02	0,07	0,29		
Communication and creative design	Communication Studies	0,06	0,13	0,00	0,02	0,04	0,24	0,093	5
	Visual communication design	0,04	0,22	0,00	0,02	0,0	0,31		
							4		

Based on the simulation above, the engineering faculty is ranked 1 (one), meaning that the best choice for a major based on the criteria compiled is to have an engineering faculty with a choice of two majors, namely architecture and electrical engineering.

4. CONCLUSION

Based on the discussion in the previous chapters, the conclusion of this study is that the use of technology in all aspects of life is unavoidably included in the process of making a decision. This research with the combination of two methods, namely AHP and SAW, can produce a selection of faculty and study program suggestions that can be used by prospective students as material for consideration in selecting majors. Based on the results of the analysis using the AHP and SAW methods, it was found that the engineering faculty was ranked 1 (one), meaning that the best choice of major based on the criteria compiled was the engineering faculty with a choice of two majors, namely architecture and electrical engineering. The limitations of this research that can be used as suggestions for further research development is to create a technology-based system that can be accessed anytime and anywhere by the user.

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