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Implementation of fuzzy analytical hierarchy process (FAHP) and TOPSIS for scholarship decision support system for the underprivable

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ABSTRACT

Scholarship is part of assistance given by organization, company, institution or person. One of the existing scholarships at SMKN 2 Bengkalis is underprivileged scholarship given to students with middle to lower economic levels. This research does for helping underprivileged scholarship selectors in SMKN 2 Bengkalis to choose who are recommended eligible students as recipients of underprivileged scholarships with set established criteria before. Fuzzy analytical hierarchy process method implemented in this research with 7. With several criteria having each 4 – 5 values. And this research uses 239 active students data in SMKN 2 Bengkalis in 2021 as a decision alternative. Testing is done with 2 methods that are black box which system has worked in accordance with expected and UAT by 79% of both respondents. After obtaining the preference value, the final results of the ranking are obtained, the order of the smallest value of the student who is most. Entitled to receive scholarship assistance, namely students 1, 5, and 10.

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1. INTRODUCTION

According to data from the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek), 75,000 students dropped out of school in the 2020/2021 academic year. Of these, 22,000 students dropped out at the high school/vocational school level, 70% of whom dropped out due to financial difficulties, and 30% due to having to work to provide for their families. Therefore, schools and the government are responsible for providing assistance to students experiencing economic difficulties or those at risk of poverty. Therefore, many institutions, organizations, and government agencies provide scholarships to underprivileged and high-achieving students as a form of support and motivation to continue their education [1-3].

A scholarship for the underprivileged is a form of financial assistance provided by organizations, institutions, or groups to students who have economic difficulties in meeting their daily needs. Scholarships for the underprivileged are awarded to students from lower-middle-class families with large family responsibilities, or to students who are vulnerable to poverty. The level of family economic capacity is determined based on the total income and expenses within a family. Families that have difficulty meeting their needs are grouped into the underprivileged category, and vice versa. Families that do not have difficulties in meeting their daily needs are categorized as families with an upper-middle economic level [4, 5].

Many attributes can be used as parameters to assess a family's economic capacity, such as (parental conditions, parental income, family expenses, number of family members, and student educational needs). Because of the numerous parameters used to determine a family's economic

capacity, human error often occurs in determining the economic capacity of students' families who receive scholarships for the underprivileged [6-8].

A decision support system is a structured and semi-structured problem-solving system. Decision support systems are a branch of artificial intelligence that replaces the role of decision-makers with predefined models. Fuzzy logic is a method for solving problems characterized by ambiguity and uncertainty [2, 4].

Based on this, the researcher took the research title "Implementation of Fuzzy AHP and TOPSIS in the Decision Support System for Underprivileged Scholarship Recipients". The results of this study are expected to be useful for teachers and Student Representatives as selectors of underprivileged scholarship assistance at SMKN 2 Bengkalis.

2. LITERATURE STUDY

2.1. Scholarships for the Underprivileged

State Vocational High School 2 Bengkalis is responsible for implementing a standardized teaching and learning process to improve the quality of education at the school. Based on this, the school is responsible for recommending students eligible for scholarships for the underprivileged to agencies, organizations, or companies currently providing scholarships. Students eligible for scholarships for the underprivileged include:

- Students who are orphans.
- Students who are poor or whose parents have low incomes and still have many dependents for their school children.
- Students who are vulnerable to poverty.
- Students who are not yet underprivileged and have never received assistance from the PIP program.

Based on this, students eligible for scholarships for underprivileged students are determined based on several criteria that can serve as necessary parameters. These criteria include student status, person responsible, average income, number of dependents, dependents currently studying, average expenses, and residence. These criteria serve as a reference in the student selection process to determine those most deserving of scholarship assistance.

2.2. Decision Support System

Decision Support System is an information system that is able to help users solve problems or is able to communicate a problem in both semi-structured and unstructured conditions. Decision support system According to Kusrini, Decision Support System is an information system that provides information that is decision-making in nature [1].

According to Simangsong and Sinaga, there are four interrelated and sequential stages in decision making, including:

- Intelligence can generally be described as the ability to prepare information and retain it as applied knowledge.
- Design is the planning for system specifications in the form of prototypes, products, and processes.
- Choice is the process of determining a choice from various aspects of search, evaluation, and solution, created according to the model.
- Implementation is applied to the system by applying the required technology and models with the goal of ensuring the DSS system runs as expected.

2.3. Fuzzy Analytical Hierarchy Process (F-AHP)

According to Muhammad Dedi Irawan, the fuzzy set theory, or fuzzy hypothesis, was first proposed by Lotfi Zadeh around 1965 in a paper entitled "Fuzzy Sets." Since then, Japanese researchers have successfully applied this theory to technical problems. Fuzzy logic is an improvement on Boolean logic that deals with the concept of partial truth. Currently, classical logic states that everything can be defined in binary terms [2].

Analytucal Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy, according to Saaty, hierarchy is defined as a representation of a complex problem. With a

hierarchy, a complex problem can be described into groups which are then arranged into a hierarchical form so that the problem will appear more structured and systematic.

Fuzzy AHP is a Decision Support System method that is a development of the AHP method for decision-making processes with many subjective criteria. Decision-makers often face problems in determining the weight of each criterion. The F-AHP method uses Triangular Fuzzy Number (TFN) in the Fuzzyfication process which consists value of minimum (1), middle (m) and maximum (u). The table below shows the scale of importance of fuzzy triangular numbers.

Table 1. Fuzzy importance intensity.

Intensity	Linguistic set	TFN	The opposite
1	Comparison of the same elements	(1,1,1)	(1,1,1)
2	Mid	(1/2,1,3/2)	(2/3,1.2)
3	One element is sufficient for the other	(1,3/2,2)	(1/2,2/3,1)
4	Approaching is more important than	(3/2,2,5/2)	(2/5,2,2/3)
5	More important than	(2,5/2,3)	(1/3,2/5,1/2)
6	Approaching is very important from	(1/2,3,7/2)	(2/7,1/3,2/5)
7	Very important from	(3,7/2,4)	(1/4,2/7,1/3)
8	Approaching absolute from	(7/2,4,9/2)	(2/9,1/4,2/7)
9	Absolutely very important of	(4,9/2,9/2)	(2/9,2/9,1/4)

2.4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a method in decision making in producing a decision that will choose an alternative that is not only closest to the positive ideal solution, but also the furthest from the negative ideal solution by using the concept of Euclidean distance. The positive ideal solution is defined as the sum of all the worst values ever achieved for each attribute. The TOPSIS method is based on the concept that the best selected alternative not only has the shortest distance from the positive ideal solution but also has the longest distance from the negative ideal solution [4].

The TOPSIS method can solve Multi-Criteria Decision Making (MCDM) problems. Furthermore, the TOPSIS method has a simple and easy-to-understand concept, efficient computation, and the ability to measure the relative performance of decision alternatives. TOPSIS will rank alternatives based on the priority of their relative proximity to the positive ideal solution. The ranked alternatives are then used as a reference in decision-making to obtain the best solution to a problem.

3. RESEARCH METHODS

Study uses the stages taken to obtain a research methodology which is a stage that must This be applied so that the research can be carried out systematically and directed to facilitate analysis of existing problems. The research stages for the Implementation of Fuzzy AHP and TOPSIS in the Decision Support System for Underprivileged Scholarship Recipients are as follows:

3.1. Problem Identification

This research began when a problem arose at SMKN 2 Bengkalis. Teachers and student representatives were having difficulty determining which students were eligible for scholarships for the underprivileged due to the numerous criteria used to qualify for the assistance.

3.2. Interviews

After identifying the problem, interviews were conducted with the Student Affairs representative and several teachers responsible for selecting scholarships for the underprivileged. This resulted in an outline of the problem, the aspects used as parameters, and the data needed for selecting scholarships for the underprivileged.

3.3. Data collection

After obtaining the aspects and criteria needed in selecting students, data is collected from each student, in addition to the data already available in the database at the Student Affairs representative, data collection is carried out on attributes that are still lacking.

3.4. Data Analysis and Methods

At this stage, analysis and calculations are carried out using the Fuzzy AHP and TOPSIS methods which will be used with existing data to obtain an overview of the system flow to be built.

3.5. System Implementation

After analyzing the data and methods to be used, the system is implemented using the methods that have been determined and the data that has been obtained.

3.6. System Testing

At this stage, it is carried out to test whether the system is running well using the available methods and data and whether the system is able to solve existing problems and provide the best solution decisions for the problems that occur.

4. RESULTS AND DISCUSSION

The author's research yielded input variables, including a student's family status, income, and economic capacity. The output variables included preference scores and recommendations for students eligible for scholarships for those in need. Further details can be found in the following discussion.

4.1. Fuzzy AHP Calculation

In the Fuzzy AHP calculation, this input variable is used as a parameter in the recommendation process for students who are entitled to receive scholarship assistance for the less fortunate.

Table 2. Criteria variables.

Code	Criteria name	Attribute
C01	Student status	Benfit
C02	Person responsible	Cost
C03	Average income	Cost
C04	Number of responsible dependents	Cost
C05	Dependents who are currently in education	Cost
C06	Average monthly expenses	Cost
C07	Residence	Benefit

The criteria in Table 2 are the results and provisions of the determination of scholarship assistance for the less fortunate which have been determined by the Student Representative and the teachers as selectors at SMKN 2 Bengkalis.

From Table 2, the input sub-criteria variables are obtained. The sub-criteria variables used are as follows.

Table 3. AHP interest intensity.

Code	C01	C02	C03	C04	C05	C06	C07
C01	1	4	3	3	1/4	4	¼
C02	1/4	1	2	4	1/2	1/3	½
C03	1/3	1/2	1	3	1/2	1	1/3
C04	1/3	1/4	1/3	1	1	4	2
C05	4	2	2	1	1	1/3	3'
C06	1/4	3	1	1/4	3	1	4
C07	4	2	3	1/2	3	1/4	1

From Table 3, the Triangular Fuzzy Number value is obtained from the sum of the values l (lower), m (middle) and u (upper) for each assessment criteria.

Table 4. Triangular fuzzy number.

Code	l	m	u
C01	6.30	11.50	10.83
C02	5.23	8.67	10.67
C03	6.17	7.83	10.50
C04	5.40	8.33	8.67
C05	5.50	7.67	10.00
C06	6.40	9.67	10.17
C07	5.57	9.50	11.17
Total	40.57	63.17	72.00

Based on the values obtained in Table 4, calculations are carried out to obtain the Fuzzy Synthesis (Si) value using the formula:

$$Si = \sum_{j=1}^{m} M_{gi}^{j} x \left[\sum_{i=0}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right] - 1 \quad (1)$$

and get the following results:

Table 5. Fuzzy synthesis value.

Code	l	m	u
C01	0.088	0.16	0.15
C02	0.073	0.12	0.148
C03	0.086	0.109	0.146
C04	0.075	0.116	0.12
C05	0.076	0.106	0.139
C06	0.089	0.134	0.141
C07	0.077	0.132	0.155

From Table 5, the criteria vector value is obtained from the priority vector value which is compared for each criterion using the formula:

$$V(M2 > M1) = \begin{cases} 1 \\ 0 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases} \begin{matrix} if\ m_2 \geq m_1 \\ if\ l_2 \geq u_2 \\ other \end{matrix} \quad (2)$$

and the formula:

$$W = (d(A1), d(A2), \ldots d(An))\ T \quad (3)$$

The weight values obtained for each criterion are as follows:

Tabel 6. Criteria weight value.

Code	Criteria name	Weight
C01	Student status	0.223
C02	Person responsible	0.135
C03	Average income	0.128
C04	Number of responsible dependents	0.095
C05	Dependents who are currently in education	0.109
C06	Average monthly expenses	0.151
C07	Residence	0.158

Based on the calculations that have been carried out using Fuzzy-AHP, the weight of each criterion is obtained which will be used for the weighting of the assessment that will be carried out in the next process.

4.2. TOPSIS Calculation

The next step is ranking using the TOPSIS method. This ranking process uses sub-criteria for each initialized criterion. The weights for each sub-criterion are obtained from interviews with the Scholarship Assistance Selectors for the Underprivileged at SMKN 2 Bengkalis. The following is a TOPSIS calculation using 10 student sample data.

Table 7. Alternative data 10 samples.

No	Alt	C01	C02	C03	C04	C05	C06	C07
1	Student 1	4	3	5	2	2	6	1
2	Student 2	1	1	5	3	1	5	1
3	Student 3	1	4	4	3	2	4	1
4	Student 4	1	1	3	3	3	5	1
5	Student 5	1	4	4	3	2	5	1
6	Student 6	1	3	4	2	1	6	1
7	Student 7	1	1	3	3	3	4	2
8	Student 8	1	1	4	2	1	5	1
9	Student 9	1	1	4	3	2	5	1
10	Student 10	2	4	3	3	2	4	3

Based on the weight table in Table 7, the normalized decision matrix value is obtained for each criterion using the formula:

$$rij = \frac{x_{ij}}{\sqrt{\sum_{i=1} mx_{ij^2}}}, i = 1,2,3,\ldots.,m; j = 1,2,3,\ldots,n \quad (4)$$

Tabel 6. Normalized matrix.

#	C01	C02	C03	C04	C05	C06	C07
1	0.756	0.356	0.399	0.231	0.312	0.383	0.218
2	0.189	0.119	0.399	0.346	0.156	0.319	0.218
3	0.189	0.475	0.319	0.346	0.312	0.256	0.218
4	0.189	0.119	0.239	0.346	0.469	0.319	0.218
5	0.189	0.475	0.319	0.346	0.312	0.319	0.218
6	0.189	0.356	0.319	0.231	0.156	0.383	0.218
7	0.189	0.119	0.239	0.346	0.469	0.256	0.436
8	0.189	0.119	0.319	0.231	0.156	0.319	0.218
9	0.189	0.119	0.319	0.346	0.312	0.319	0.218
10	0.378	0.475	0.239	0.346	0.312	0.256	0.655

After obtaining the results from the matrix normalization, the next step is to determine the ideal solution matrix for each criterion. For criteria with a cost attribute, positive values are the MIN value and negative values are the MAX value from the table. For criteria with a benefit attribute, positive values are the MAX value, and vice versa.

Tabel 7. Ideal solution matrix.

Criteria	C01	C02	C03	C04	C05	C06	C07
Attribute	Cost	Cost	Cost	Benefit	Benefit	Cost	Cost
Positive	0.042	0.119	0.180	0.260	0.234	0.192	0.055
Negative	0.168	0.475	0.299	0.173	0.078	0.287	0.164

After obtaining the positive ideal solution and negative ideal solution values for each criterion, calculations are performed to obtain preference values for each alternative. From the preference values obtained, the final ranking results are as follows.

Tabel 8. Preference value of each alternative alternative.

Alternative	Positif	Negative	Preference	Rank
1	0.4046	0.1791	0.3069	1
2	0.2743	0.4055	0.5965	6
3	0.3940	0.2329	0.3715	5
4	0.1911	0.4507	0.7022	9
5	0.4159	0.2176	0.3435	2
6	0.3940	0.2134	0.3513	4
7	0.1371	0.4484	0.7658	10
8	0.2683	0.4006	0.5989	7
9	0.2150	0.4172	0.6600	8
10	0.3917	0.2102	0.3493	3

Based on Table 8, the results show that student 1, student 5 and student 10 are the 3 students who are most entitled to receive scholarship assistance for the less fortunate.

4.3. Implementation on Web-Based System

In the implementation of the application, it can be seen as follows:

4.3.1. Assessment Criteria

The assessment criteria are obtained from Table 2 and can be seen in the following image.

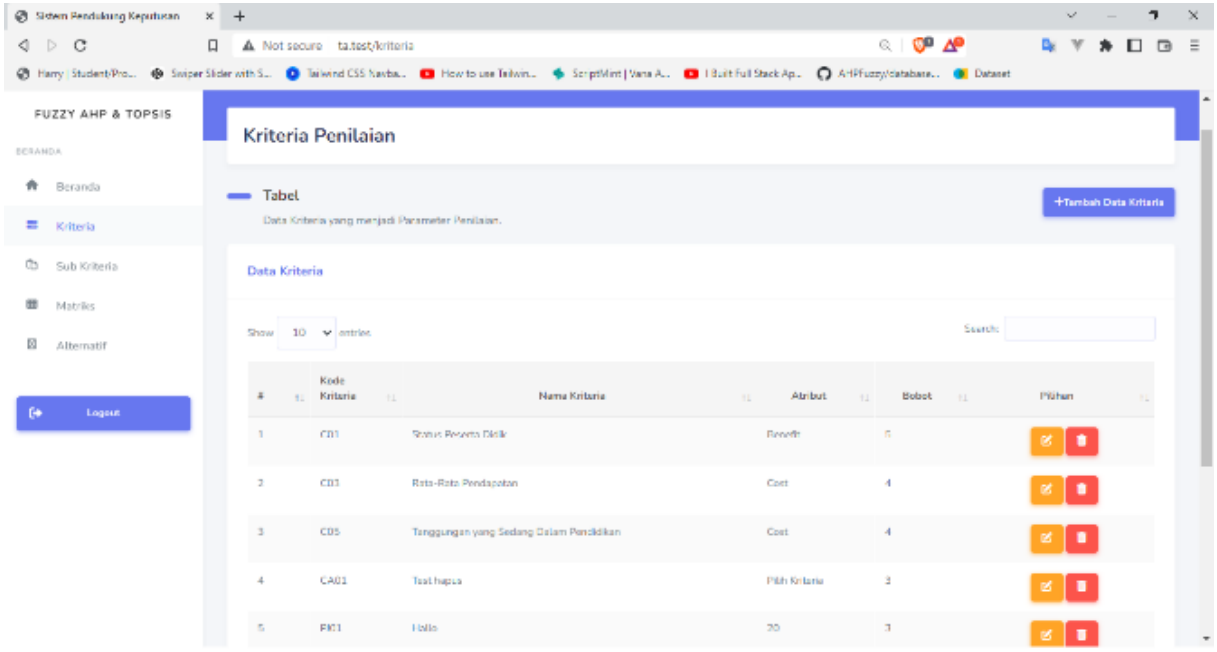

Figure 1. Assessment criteria menu.

The image above shows the criteria used in the assessment process. The criteria can be adjusted to meet existing needs and can be added or removed as needed by the Underprivileged Scholarship Assistance Selection Committee at SMKN 2 Bengkalis.

4.3.2. Criteria Matrix, Fuzzy Synthesis Value and Weight of Each Criteria

The criteria matrix is obtained from a comparison between one criterion and another criterion to produce a matrix using the Triangular Fuzzy Number concept using l (lover), m (midle), and u (upper).

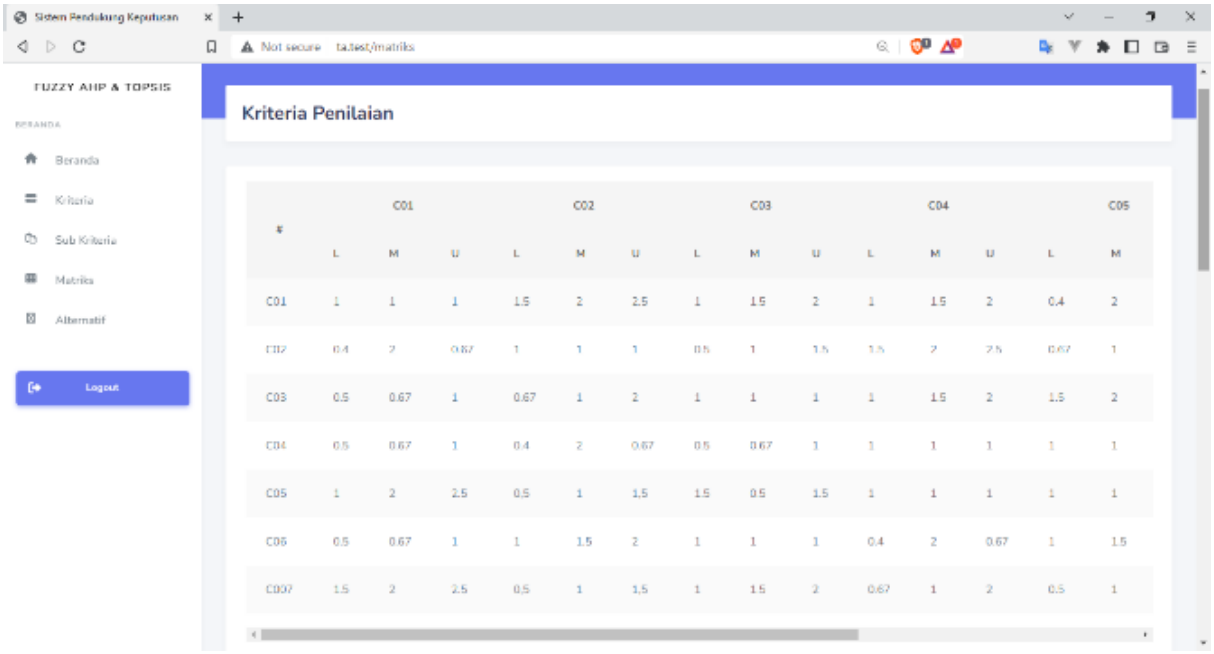

Figure 2 Triangular fuzzy number matrix.

From Figure 2, the Fuzzy Synthesis Value is calculated from the calculation of the Triangular fuzzy number value. And the criteria weight is obtained based on the priority vector value obtained from the Fuzzy Synthesis value.

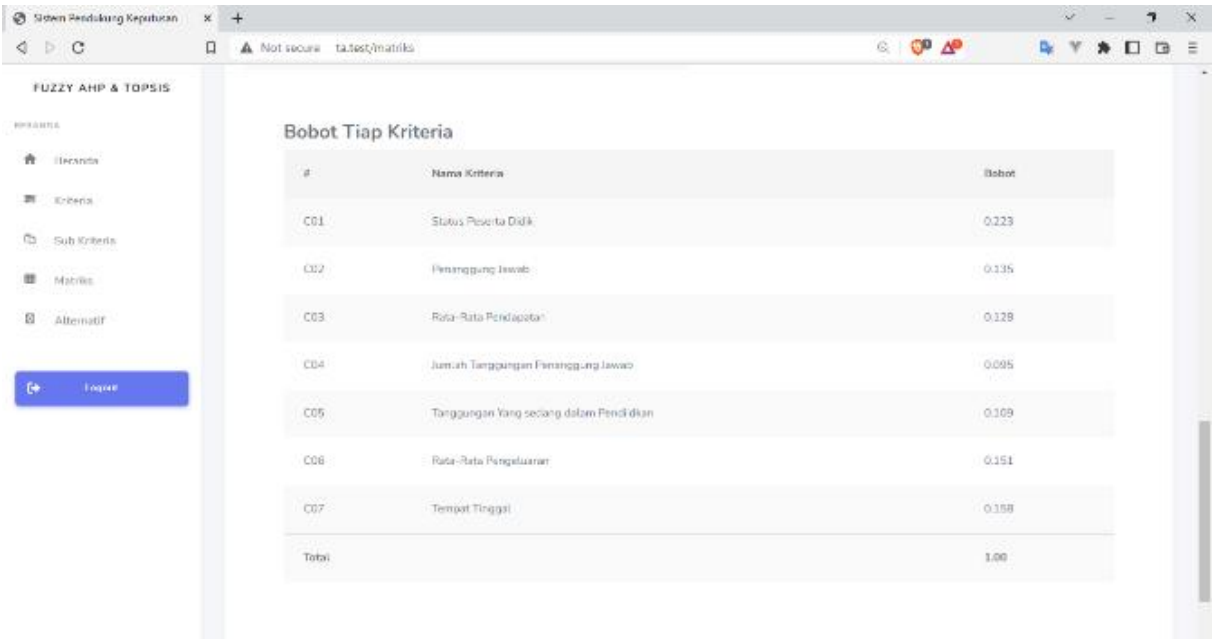

Figure 3. Alternative data weighting criteria.

The alternatives below are labels that are output from aid recipients whose values have been obtained from the calculations in Table 8.

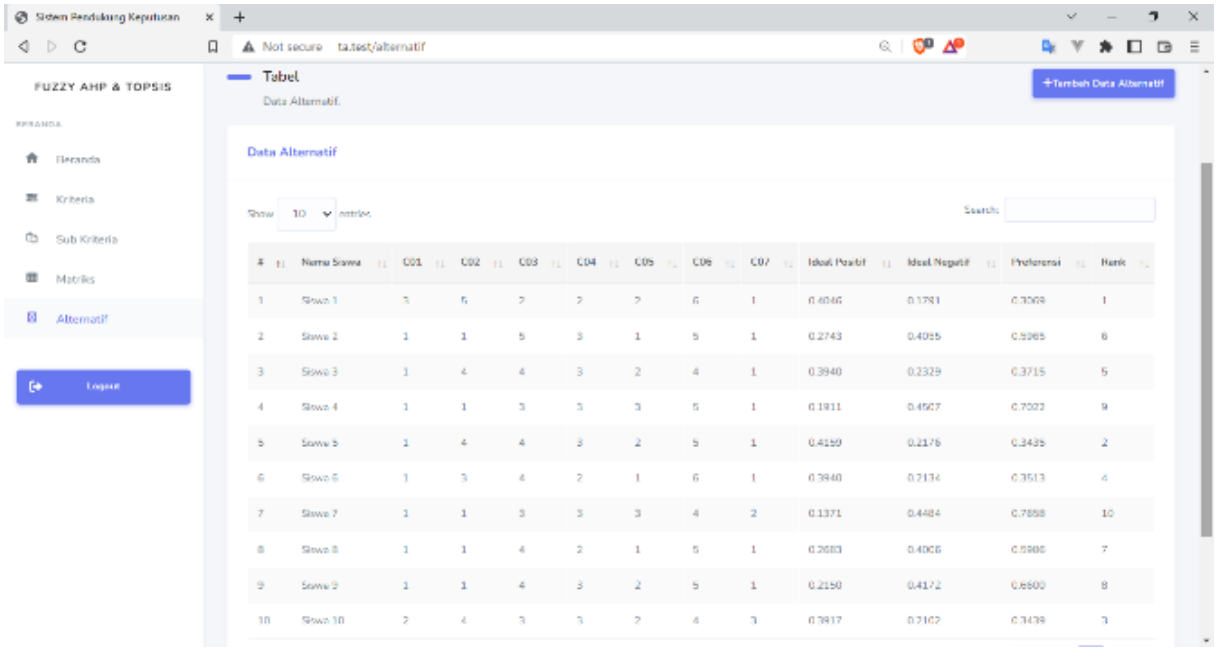

Figure 4. Alternative table, reference values and recommendations for aid recipients.

5. CONCLUSION

Based on research, implementation and testing, the following conclusions can be drawn:

- A decision support system for scholarship recipients for the underprivileged was successfully developed using the Fuzzy AHP and TOPSIS methods.
- The decision support system successfully generated recommended output for scholarship recipients for the underprivileged.
- The decision support system was able to provide a solution to the problems encountered in the scholarship selection process at SMKN 2 Bengklais.
- Based on the calculations performed using the TOPSIS method, preference values were obtained from the positive ideal solution and the negative ideal solution. After obtaining the preference values, the preference values, sorted from the lowest value, were obtained for the students most deserving of scholarship assistance for the underprivileged: students 1, 5, and 10.

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