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Analysis and Development of a Decision Support System for Selection of Prospective KIP Scholarship Recipients

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ABSTRACT

Global Institute of Technology and Business Campus (Global Institute) is one of the campuses that organizes the KIP (Kartu Indonesia Pintar) scholarship program. This program aims to increase access to education for children from disadvantaged families and provide them with financial support. The research methods used are needs analysis, system design, and prototype implementation. This research collects data from various sources, including personal data of prospective scholarship recipients, academic data, family income data, and other relevant factors. The data collected is then analyzed using appropriate decision making methods, such as the Analytical Hierarchy Process (AHP) and TOPSIS methods. A Decision Support System is an interactive platform that helps make decisions efficiently and effectively in the process by presenting alternatives resulting from data processing, information, and the design of interactive computer-based models or systems. This platform provides support to decision makers in utilizing data and models to overcome unstructured problems.

1. Introduction

The KIP College Scholarship is a very important initiative to increase access to higher education for Indonesian students from economically disadvantaged backgrounds. In the context of economic growth and increasingly fierce global competition, higher education is considered the key to preparing Indonesia's young generation to be able to compete at the national and international levels. Despite this, the cost of higher education is often a major challenge for many students who come from families with limited resources [1], [2].

To overcome inequality in access to higher education, the Indonesian government has taken strategic steps by providing KIP College Scholarships. This scholarship aims to provide equal opportunities for all students who have the academic potential to continue higher education without being burdened by high education costs [3].

Global Institute of Technology and Business (Global Institute) opened the KIP scholarship program in 2016 and implemented it by applicable selection procedures. In providing KIP scholarships, the only main requirement is to have a KIP card, because of this, Global Institute of Technology and Business must screen recipients because the number of applicants is more than the quota given by the Government. So far, the New Student Admissions Committee team has carried out screening through several methods, including conducting academic tests and interviews. However, in the screening process stage, many participants had the same grading results or could be said to have the same average score. Based on these conditions, the PMB Committee decided to accept prospective KIP students using the interview method at the end of the process, which according to most of the Committee still resulted in subjectivity from the interviewers.

Rahmat Tullah and his team in 2018, Decision Support System for Selection of Bidikmisi Scholarship Recipient Candidates using the AHP and TOPSIS Methods at STMIK Bina Sarana Global. The system for selecting bidikmisi scholarship recipients is carried out in two stages, namely the first stage is calculating the weighting of the criteria. The criteria used in this research include; 1) Parent's Salary; 2) Average report card score; 3) Academic Test Scores; 4) Achievements obtained; 5) Number of dependents of parents. With their respective priority weights (w):

a. Total Parental Salary (Salary) is 6,568
b. The average report card score (Average Value) is 6.214
c. Academic Test Score (Test Score) is 6.009
d. The achievement obtained (Achievement) was 5,778
e. The number of dependents (Dependents) is 5,502

In the second stage, after the criteria weights have been obtained, candidates are then entered by inputting data according to the criteria used. The results obtained in the TOPSIS system process can display the ranking of each candidate, so that the names of those who are entitled to a scholarship are obtained according to the number of available quotas.

Arfyanti in 2021 [4], Application of the Technique for Orders Preference by Similarity to Ideal Solution (TOPSIS) and Rank Order Centroid (ROC) Methods in Providing Smart Indonesia Card (KIP) Scholarships. Providing KIP scholarships in accordance with procedures means that students prepare the required documents and as a requirement from the government, then the school records data on students who are potential recipients of KIP assistance by selecting who is entitled based on supporting data and data from the school itself and then sorting it again or filtering it. From a lot of student data to be submitted or proposed to the relevant Department. This makes it mandatory for schools to select students who will be proposed so that there are no mistakes in providing suitable KIP scholarship recipients. The results of data searches from KIP scholarship recipients are easier to process, resulting in more precise and objective data. The ROC method is one of the simplest weighting methods in the process and is very easy to understand. The use of the ROC method helps cover the shortcomings and weaknesses of the TOPSIS method so that the results of decision making become more accurate and optimal. And the data listed in the results and discussion is data that has the right to be submitted, determined and nominated as a student who is worthy of being a KIP scholarship recipient.

2. Method

2.1 Decision Support System

A decision support system is an interactive information system that can provide information. DSS is used to assist decision making in various situations, both semi-structured and unstructured [5].

There are 3 objectives achieved by a Decision Support System [6], namely: [7] (1) Helping decision makers in making the best decisions that can be used to solve semi-structured problems. (2) As a supporter of the decision maker's assessment, not to replace supporters. (3) More emphasis on effectiveness in decision making.

2.2 Analytical Hierarchy Process (AHP)

AHP is an approach method that is suitable for handling complex systems that are related to determining decisions from several alternatives and providing options that can be considered. Procedures or steps in the AHP method include [5]:

1. Define the problem and determine the desired solution, then arrange a hierarchy of the problems faced. Arranging a hierarchy is setting goals which are the targets of the system as a whole at the top level.
2. Determining Element Priorities. The first step in determining element priorities is to make pairwise comparisons, namely comparing elements in pairs according to the given criteria. The pairwise comparison matrix is filled in using numbers to represent the relative importance of one element to other elements.
3. Synthesis Obtaining overall priorities will require the considerations of pairwise comparisons to be synthesized. In this step, the things that are done are adding up the values from each column in the matrix, dividing each value from the column by the total of the column in question to obtain a normalized matrix, adding up the values from each row and dividing it by the number of elements to get the value average.
4. Measuring Consistency. What is done in this step is to multiply each value in the first column by the relative priority of the first element, the value in the second element by the relative priority of the second element, and so on, then add up each row and the result of adding the rows is divided by the element's relative priority concerned. Adding the quotient above to the number of elements present is called l max.
5. Calculate the Consistency Index (CI) Formula: CI = (1) Where n = number of elements
6. Calculate the Consistency Ratio (CR) Formula: CR= CI/IR (2) Where CR = Consistency Ratio, CI = Consistency Index, and IR = Random Consistency Index
7. Checking Hierarchy Consistency. If the value is more than 100%, then the judgment data assessment must be corrected. However, if the consistency ratio (CI/IR) is less than or equal to 0.1, then the calculation results can be declared correct.

2.3 TOPSIS

TOPSIS is a method that can help the optimal decision making process to solve decision problems practically. This is because the concept is simple and easy to understand, computationally efficient and has the ability to measure the relative performance of decision alternatives in simple mathematical form [8].

2.4 Research Design

Research design used in Analysis and Development of Decision Support Systems for Selection of KIP Scholarship Recipient Candidates. The following figure 1 is the research design for analysis and development of a decision support system for selecting prospective recipients of KIP scholarship.

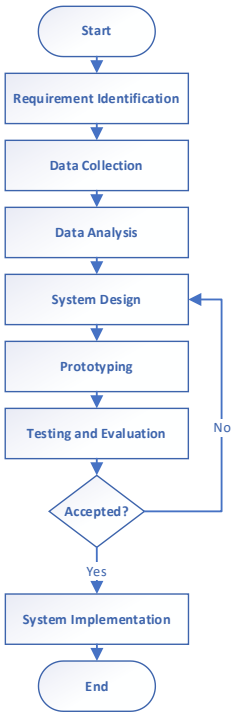

Figure 1. Research Design

a. Requirements Identification

Surveys or interviews with stakeholders [9], [10], such as aid providing agencies and potential recipients, are conducted to understand the needs and requirements that must be met by the decision support system. Additionally, a review of related documents and literature is undertaken to gain a better understanding of the current process for selecting potential KIP recipients.

b. Data Collection

The identification of data required for the selection of potential KIP recipients encompasses various aspects, including demographic information, financial records, educational backgrounds, and other pertinent data. These data are gathered through surveys, existing databases, or other available data sources, ensuring comprehensive coverage and accuracy in the selection process.

c. Data Analysis

Data analysis is conducted to identify patterns, relationships, and key criteria relevant to the selection of potential KIP recipients [11], [12]. Statistical methods or other appropriate data analysis techniques are employed to analyze the collected data systematically. This ensures a thorough understanding of the data and facilitates informed decision-making in the selection process.

d. System Design

The design of a decision support system is based on the identified needs and requirements. Implementation involves the incorporation of decision-making methods such as the Analytical Hierarchy Process (AHP) and TOPSIS to aid in selecting potential KIP recipients. Criteria for the system and corresponding decision rules are determined to ensure alignment with the objectives and facilitate effective decision-making processes [13].

e. Prototyping

Implement the prototype of the decision support system based on the established design. Utilize technology or programming languages that align with the requirements and resource availability.

f. Testing and Evaluation

Perform testing on the prototype system using test data or simulation data. Evaluate the system's performance, including speed, accuracy, and reliability. Gather feedback from users or relevant experts to enhance the system [14].

g. System Implementation

Integrate the decision support system with relevant data sources, such as the KIP applicant database and other pertinent information. Provide training to users who will utilize the system to ensure a thorough understanding of its usage and benefits. Conduct periodic evaluations of the system and make improvements as necessary to maintain its effectiveness.

3. Result and Discussions

3.1 Calculation of Criteria Weighting using the AHP Method

In the initial process, criteria will be determined and criteria weights calculated using the AHP method [15]. In the calculation process, the researcher will display two calculations carried out with the help of Excel and the system that has been created. This is done to ensure that the results of calculations carried out manually using Excel can be compared directly with calculations carried out using the system that has been created. The criteria that will be used in this research are; 1) Completeness of Requirement Documents (KIP Card); 2) Academic Achievement; 3) Family Income Level; 4) Academic Potential Test Scores and 5) Non-Academic Achievement. The scoring of criteria also can be seen at table 1 below.

Table 1. Score of Criteria

Data was obtained through interviews with each prospective student				
Code	*Criteria*	*Rate*	*Sub-Criteria*	*Score*
C1	KIP Card	5	Very Potential	Have had a KIP card since school
		4	Potential	Already have KIP after graduation
		3	Potential Enough	Currently in the process of applying for a KIP
		2	Less Potential	Don't have a KIP card and haven't taken care of it yet
		1	Very Less Potential	Don't have KIP card and haven't taken care of it yet also not classified as a pre-prosperous family
C2	Average of School Grades	5	Very Good	> 80
		4	Good	70 - 79
		3	Good Enough	60 - 69
		2	Not Good Enough	50 - 59
		1	Not Good	< 50
C3	Parental Income	5	Very Potential	< Rp. 1.000.000
		4	Potential	Rp 1.000.000 – Rp 1.999.999
		3	Potential Enough	Rp 2.000.000 – Rp 2.999.999
		2	Less Potential	Rp 3.000.000 – Rp 3.999.999
		1	Very Less Potential	Rp 4.000.000 – Rp 5.000.000
C4	Academic Potential Test Scores	5	Very Good	> 80
		4	Good	70 - 79
		3	Good Enough	60 - 69
		2	Not Good Enough	50 - 59
		1	Not Good	< 50
C5	Achievement	5	Very Good	4 Achievements
		4	Good	3 Achievements
		3	Good Enough	2 Achievements
		2	Not Good Enough	1 Achievement
		1	Not Good	0 Achievement

After inputting the criteria, the next step is for the researcher to carry out pairwise weighting of each criterion with weight values as in table 2 below.

Table 2. Pairwise comparison importance element scale

Weight Value	*Pair Criteria*
1	As important as
2	Getting a little closer more to important

3	A little more important than
4	A little closer more important than
5	More important than
6	A little closer very important than
7	Very important than
8	Getting a little closer more to absolute
9	Absolutely very important of

Table 3. Pairwise weight assessment of each criterion

	Criteria 1	*Weight*	*Criteria 2*
1	KIP Card	9- Absolutely very important of	Average of School Grades
2	KIP Card	2- Getting a little closer more to important	Parental Income
3	KIP Card	5- More important than	Academic Potential Test Scores
4	KIP Card	3- A little more important than	Achievement
5	Average of School Grades	2- Getting a little closer more to important	Parental Income
6	Average of School Grades	1- As important as	Average of School Grades
7	Average of School Grades	2- Getting a little closer more to important	Achievement
8	Parental Income	4- A little closer more important than	Academic Potential Test Scores
9	Parental Income	5- Absolutely very important of	Achievement
10	Academic Potential Test Scores	1- As important as	Achievement

First, construct a hierarchy, starting with objectives, criteria and location alternatives at the lowest level. Next, determine pairwise comparisons between the criteria in matrix form. The diagonal value of the matrix for the comparison of an element with the element itself is filled in with the number 1 while the opposite is filled in with the comparison value between 1 to 9, then added up per column. The matrix data is as shown in table 4 below.

Table 4. Criteria Comparison Matrix

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*
C1	1	9	2	1	1
C2	0.111	1	2	1	2
C3	0.5	0.5	1	4	5
C4	1	1	0.25	1	1
C5	1	0.5	0.2	1	1
Total	**3.611**	**12**	**5..45**	**8**	**10**

After the comparison matrix is formed, the priority weights for comparison criteria are looked at. By dividing the contents of the comparison matrix by the corresponding number of columns, then adding up the rows after which the sum result is divided by the number of criteria to find the priority weight as shown in the table 5 below.

Table 5. Criteria priority weight calculation matrix

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	***Weight***
C1	0.277	0.75	0.367	0.125	0.1	**0.324**
C2	0.031	0.083	0.367	0.125	0.2	**0.161**
C3	0.138	0.042	0.183	0.5	0.5	**0.273**
C4	0.277	0.083	0.046	0.125	0.1	**0.126**
C5	0.277	0.042	0.037	0..125	0.1	**0.116**

To determine the consistency of the comparison matrix, multiply the entire contents of column A of the comparison matrix with the priority weights of criterion A, the contents of column B of the comparison matrix with the priority weights of criterion B and so on. Then add up each row and divide the sum of the rows with the corresponding priority weight as shown in the table 6 below.

Table 6. Criteria Consistency Matrix

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**Weight**
C1	0.277	0.75	0.367	0.125	0.1	7.914
C2	0.031	0.083	0.367	0.125	0.2	6.829
C3	0.138	0.042	0.183	0.5	0.5	5.868
C4	0.277	0.083	0.046	0.125	0.1	6.302
C5	0.277	0.042	0.037	0.125	0.1	6.042

3.2 Calculating of Rank using TOPSIS Method

In the simulation in this research, the researcher entered five candidates by filling in training data for each criterion as table 7 below:

Table 7. Simulation Data

Name	*KIP (Adm)*	*Average Score*	*Parental Income*	*Academic Potential Test Scores*	*Achievement*
Ahmad Zaki	5 (Very Potential)	5 (>80)	4 (3-3,9 jt)	3 (60-69)	4 (3 Achievement)
Indah Sari	4 (Potential)	5 (>80)	4 (3-3,9 jt)	3 (60-69)	5 (4 Achievement)
Ryo Nugraha	5 (Very Potential)	5 (>80)	3 (2-2,9 jt)	4 (70-79)	4 (3 Achievement)
Ahmad Jaenudin	3 (Potential Enough)	5 (>80)	5 (4-5 jt)	4 (70-79)	4 (3 Achievement)
Jaka Sudrajat	3 (Potential Enough)	4 (70-79)	4 (3-3,9 jt)	4 (70-79)	4 (3 Achievement)

At this stage the decision matrix that has been prepared is then normalized so that each data value for each criterion has the same length. The decision matrix is normalized with the following formula (1) below:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (1)$$

Notes: i rows = 1,2,…..,m ; and

j columns = 1,2,…..,n

Table 8. Calculation

	Criteria				
Alternative	*KIP (Adm)*	*Average Score*	*Parental Income*	*Academic Potential Test Scores*	*Achievement*
A1	5	5	4	3	4
A2	4	5	4	3	5
A3	5	5	3	4	4
A4	3	5	5	4	4
A5	3	4	4	4	4
	9.16515139	10.77032961	9.055385138	8.124038405	9.433981132
A1	25	25	16	9	16
A2	16	25	16	9	25
A3	25	25	9	16	16
A4	9	25	25	16	16
A5	9	16	16	16	16
SUM	84	116	82	66	89
SQRT	9.16515139	10.77032961	9.055385138	8.124038405	9.433981132

Table 9. Result of normalization calculation

	Criteria				
Alternative	*C1*	*C2*	*C3*	*C4*	*C5*
A1	0.54554	0.46424	0.44173	0.36927	0.42400
A2	0.43644	0.46424	0.44173	0.36927	0.53000
A3	0.54554	0.46424	0.33129	0.49237	0.42400
A4	0.32733	0.46424	0.55216	0.49237	0.42400
A5	0.32733	0.37139	0.44173	0.49237	0.42400

After normalization calculation, the next stage is Weighted Normalization. At this stage, the purpose of weighted normalization is, among other things, to calculate priority criteria. In the TOPSIS method,

criteria weights are applied after normalization, thereby illustrating how important each criterion is in decision making. Criteria with higher weights will have a greater impact on the final assessment. Weighted normalization also helps identify positive ideal solutions and negative ideal solutions. This solution becomes a reference in determining how far each alternative is close to the best solution or how far they are from an undesirable solution. Normalization ensures that these calculations are fair and produce objective results.

Table 10. Weighted Normalization

	C1	C2	C3	C4	C5
A1	0.17664	0.07484	0.12047	0.04661	0.04921
A2	0.14131	0.07484	0.12047	0.04661	0.06151
A3	0.17664	0.07484	0.09035	0.06215	0.04921
A4	0.10598	0.07484	0.15059	0.06215	0.04921
A5	0.10598	0.05987	0.12047	0.06215	0.04921

The next is Ideal Solution Matrix. At this stage, the ideal solution matrix consists of 2 parts, namely, the positive ideal solution (A+) and the negative ideal solution (A-). For a positive ideal solution it is a reference point that shows the best value for each criterion. Systematically, the positive ideal solution (A_) for each criterion.

Table 11. Ideal Solutions Matrix

	C1	*C2*	*C3*	*C4*	*C5*
Positive	0.17664	0.07484	0.09035	0.06215	0.06151
Negative	0.10598	0.05987	0.15059	0.04661	0.04921

The weighted normalized matrix that has been obtained is then used to determine the positive ideal solution. The positive ideal solution is obtained by finding the maximum value of all alternatives for each criterion in the weighted normalized matrix, if the criterion is a profit criterion where the largest value is the best value. On the other hand, a positive ideal solution is obtained by finding the minimum value of all alternatives for each criterion in the weighted normalized matrix, if the criterion is a cost criterion where the largest value is the worst value.

After obtaining a positive ideal solution, the distance from each alternative can be calculated to obtain the approximate distance of each alternative to the positive ideal solution. The distance of approach to the positive ideal solution is obtained by the formula (2):

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(y_i^+ - y_{ij})q^2} \qquad (2)$$

Likewise, after obtaining a negative ideal solution, the distance from each alternative can be calculated to obtain the approximate distance of each alternative to the negative ideal solution. The distance of approach to the negative ideal solution is obtained by the formula (3):

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)q^2} \qquad (3)$$

The final step in the analysis of determining KIP scholarship recipients is calculating the preference value, where the alternative that has the greatest preference value is the chosen alternative. Calculating the preference value or relative closeness distance is done by dividing each alternative distance to the negative ideal solution by the sum of the alternative distances to the positive ideal solution and the alternative distance to the negative ideal solution.

So that alternative distances to positive and negative ideal solutions and preference values are obtained as follows.

Table 12. Solution Distance and Preference Value

	Positive	*Negative*	*Preference*
A1	0.03605	0.07825	0.68459
A2	0.04895	0.0503	0.5068
A3	0.0123	0.09532	0.88569
A4	0.09366	0.02157	0.18723
A5	0.07921	0.03389	0.29963

Based on the preference solution values in table 12, the prospective KIP scholarship recipients Global Institute of Technology and Business can be ranked in table 13 below.

Table 13. Rank

Alternative - Name	*Total*	*Rank*
A1 – Ahmad Zaki	0.685	2
A2 – Indah Sari	0.507	3
A3 – Ryo Nugraha	0.886	1
A4 – Ahmad Jaenudin	0.187	5
A5 – Jaka Sudrajat	0.3	4

3.3 Decision Support System

Inputting criteria into the system, along with the results of inputting criteria into the system that has been designed in figure 2 below.

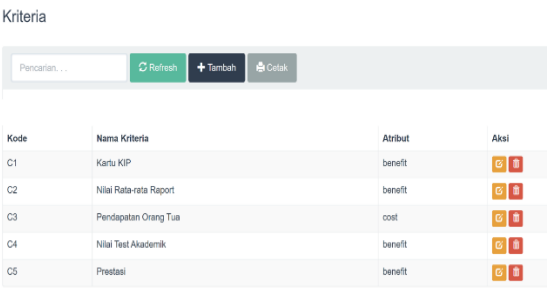

Figure 2. Criteria AHP on system

The input results of the criteria weight assessment in the system created in figure 3 below.

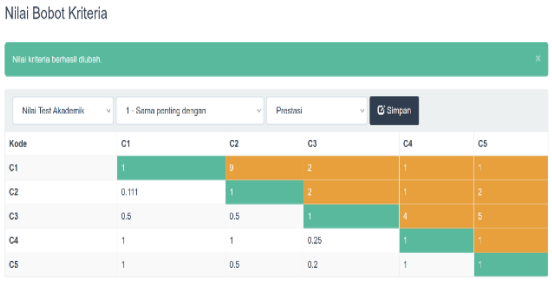

Figure 3. Criterion pairwise comparison matrix through system

The last result of ranking also can be seen in this system like in figure 4 below.

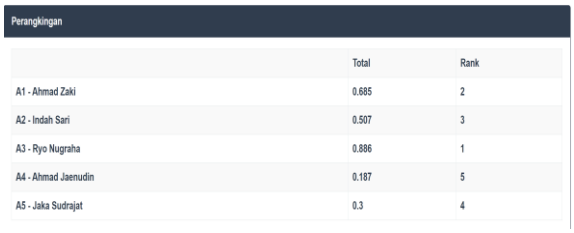

Figure 4. Ranking table on system

4. Conclusion

Based on the results of the previous discussion, decisions in selecting prospective KIP scholarship recipients can be supported and improved by using a decision support system quickly and precisely. Accurate and comprehensive data collection is an important factor in implementing data analysis and SPK models, the selection process can be more objective, efficient and accurate. Relevant and representative data is needed so that the DSS model can provide better results. These criteria must include factors such as socio-economic conditions, academic performance, and required administrative needs. Data analysis helps explore information and patterns from existing data, so that it can provide better insight in decision making. Developing a DSS model requires selecting methods and techniques that suit the needs and characteristics of the data. Statistical models, classification models, or a combination of the two may be used depending on the objectives and complexity of the problem. The conclusions above are general and depend on the context, objectives and data used in research and development of decision support systems for selecting prospective KIP scholarship recipients. It is important to involve experts and related parties in the development process to ensure the suitability and success of system implementation.

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