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Decision Support System Model for College Kartu Indonesia Pintar (KIP) Scholarship Recipients Using the C4.5 Decision Tree Method and Simple Additive Weighting (SAW)

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ABSTRACT

The KIP-Kuliah Scholarship is an Indonesian government program that is used to help high school students (SMA) or equivalent who are less capable but have academic potential in financing education in college. In this study, the problem limitation or scope of research is at Prof. DR. HAMKA Muhammadiyah University College in the Management Study Program. In each year the selection of scholarship acceptance often changes criteria, because of the frequent changes in scholarship criteria each year users often experience problems in selecting KIP-Kuliah scholarship recipients. Decision Support System (SPK) is a solution to assist in decision making. The purpose of this research is to assist in decision making in determining scholarship recipients in accordance with existing criteria. The method used in this research is using Decision Tree C4.5 to determine the weight of the KIP-Kuliah scholarship criteria and the Simple Additive Weighting (SAW) method is used to determine the ranking of scholarship recipients. In this study, researchers used 3 criteria, namely the amount of parents' income, the number of dependents, and the interview test scores. The results of the analysis of the calculations using the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods and the results of the selection of college KIP scholarships consisting of the criteria for the amount of parents' income, the number of dependents and the interview test, the 12 students who deserve college KIP scholarships are students who get the highest preference scores, namely M11, M3, M6, M4, M14, M1, M5, M12, M10, M2, M7, and M9. In conclusion, the use of a Decision Support System with the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods is effective in helping determine the recipients of the KIP-Kuliah scholarship in accordance with predetermined criteria.

1. Introduction

A scholarship is a form of reward to a student or university student during their education [1]. Scholarships can be given by educational institutions or the government to those who excel but have financial limitations to complete their studies. Every year, Prof. DR. Hamka Muhammadiyah University provides various types of scholarships to outstanding but underprivileged students. The Kartu Indonesia Pintar Kuliah (KIP-Kuliah) scholarship is a form of educational assistance provided to students who come from families with economic limitations and show achievements in both academic and non-academic fields. The purpose of the KIP-Kuliah program is to increase access and learning opportunities for students from these circles at colleges or universities [2]. The establishment of scholarship quotas through the The Kartu Indonesia Pintar Kuliah (KIP-Kuliah) is important, in accordance with Law No. 12/2012 on Higher Education. The Indonesian government has an obligation to increase access and opportunities to study in higher education, as well as to create smart and competitive Indonesians [3]. Therefore, the Government is committed to ensuring that underprivileged Indonesian children, especially those with achievements, can continue their education up to college level through the Program Indonesia Pintar (PIP) which is implemented through the The Kartu Indonesia Pintar Kuliah (KIP-Kuliah) [4], [5]. In this context, the provision of assistance through the The Kartu Indonesia Pintar Kuliah (KIP-Kuliah) should be channeled to students who are eligible to receive such assistance. This is in line with the Government's efforts to support education and ensure that underprivileged individuals, especially those with merit, can still pursue their education [6]. Therefore, in this case, the problem that is often encountered in determining the eligibility

of KIP recipients in accordance with the government program is determining who really deserves KIP, so that the program run by the government is in accordance with the targets and criteria in its provision. Especially in 2020 and 2021 due to the pandemic, the additional criteria provided by Prof. DR. Hamka Muhammadiyah University are only interview test criteria, which were originally academic tests and interview tests. In receiving scholarships, there are often problems, namely the frequent changes in criteria in the selection of scholarship recipients each year, besides that, there are often inaccuracies in the distribution of scholarship recipients, for example students who do not meet the scholarship criteria but get scholarships, and vice versa for students who meet the scholarship criteria but do not get scholarships. In addition, the problems that occur are the result of human error, such as lack of accuracy during the selection of scholarship recipients. The selection and determination of students who are eligible for scholarships is a complicated process, because there are many opportunities to make wrong and ineffective decisions.[7], [8], [9].

In some previous studies, there are studies that are related or relevant to the current research, namely research on decision support systems in scholarship acceptance, namely the Simple Additive Weighting (SAW) method [10], [11], [12] Previous research [13], [14] also discusses decision support systems in receiving Kartu Indonesia Pintar (KIP) scholarships, but what distinguishes this research is the method used and the object or place of the institution. This research aims to Design and build a decision support system to determine KIP scholarship recipients with the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods, and to be able to determine the level of accuracy in determining scholarship recipient decision making using the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods.

The purpose of this research is to assist in decision making in determining scholarship recipients in accordance with existing criteria. The method used in this research is using Decision Tree C4.5 to determine the weight of the KIP-Kuliah scholarship criteria and the Simple Additive Weighting (SAW) method is used to determine the ranking of scholarship recipients. In this study, researchers used 3 criteria, namely the amount of parents' income, the number of dependents, and the interview test scores.

In this study the authors used a decision support system model with the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods, the Decision Tree C4.5 method was used to find the weight of the criteria while the Simple Additive Weighting (SAW) method was used for selecting scholarship recipients. With the support of a decision support system application that uses the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods, it is hoped that it can provide solutions to several problems that occur in the selection of KIP-Kuliah scholarship recipients.

2. General Instructions

The system is a unit of effort consisting of parts that are regularly related to each other which try to achieve one goal in a complex environment [15]. Decision support systems are defined as computer-based systems consisting of interacting components, namely: language systems, knowledge systems, and problem processing systems [16], [17]. The research method regarding the analysis of the scholarship recipient decision support system model can be carried out in several stages. The stages include: preliminary stage, data processing stage, analysis stage, implementation stage and testing stage. The steps at the stages of implementing this research can be seen in Figure 1.

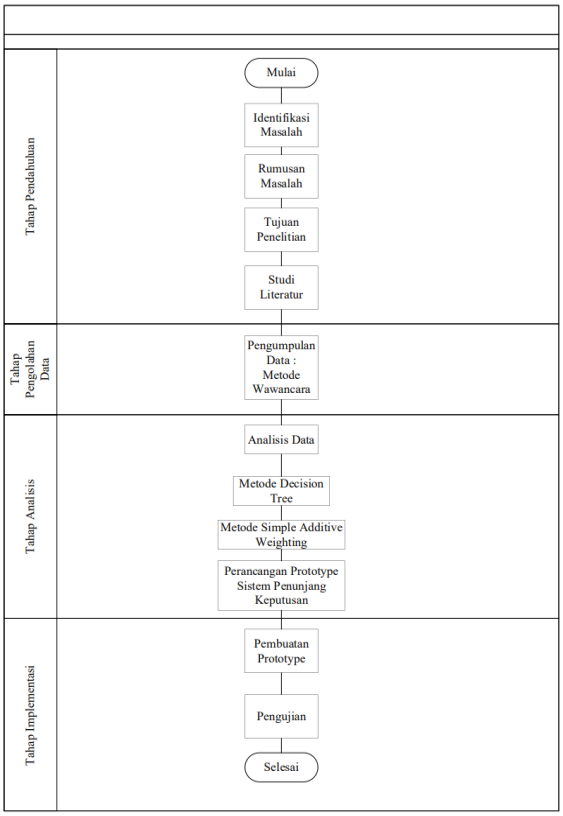


Figure 1 Steps of the research phase

2.1 Simple Additive Weighting (SAW)

Simple Additive Weighting (SAW) is one of the methods of the Multiple Attribute Decision Making (MADM) methodology [18]. SAW which is also referred to as a weighted linear combination or scoring method is a simple and most commonly used multi-attribute decision technique[19], [20].

2.2 Decision tree

In decision-making problem-solving analysis, a tree is a visual representation of the various alternatives that can be taken to solve the problem. The tree includes probability factors that may affect each

decision alternative. In addition, the tree also provides an estimate of the possible outcomes if an alternative decision is taken[21].

2.3 Algorithm C4.5

The C4.5 algorithm is a method used to create decision trees, which is one of the most effective and popular classification and prediction techniques. This decision tree technique transforms complex data into a decision tree structure that describes rules in a way that is easy to understand in human language [22].

3. Result and Discussion

3.1 Problem analysis

In this research, a case study was conducted at a university that will provide a scholarship for the The Kartu Indonesia Pintar Kuliah (KIP-Kuliah) provided by the Ministry of Research, Technology and Higher Education. The process of selecting scholarship recipients has requirements. One of the research variables is the attributes or criteria determined by the Education Financing Service Center of the Ministry of Education and Culture as stated in the 2021 Introduction:

1. Split your introduction into several paragraphs, at most four paragraphs
2. The first paragraph of your introduction should describe the elements stated in your title, please state at least one reference in this paragraph
3. The second paragraph should explain the significances of at least five (5) previous researches related with your research, and describe how your research extend or different from the previous researches
4. The third paragraph should include purpose and brief method of your research explicitly
5. Give brief explanation on the method implemented in your research guidebook as well as additional criteria from universities. The criteria (attributes) of the requirements that must be met by students to be designated as scholarship recipients are as follows:
    a. The combined gross income of parents / guardians is at most IDR 4,000,000 (four million rupiah) per month.
    b. 2. The number of dependents is based on the dependents of the student's parents or guardians listed on the family card.
    c. Pass the interview test selection in this case the Muhammadiyah Prof. DR. HAMKA University organizes.

3.2 Simulation of KIP Tuition Scholarship Calculation with Decision Tree C4.5 and Simple Additive Weighting (SAW) Methods.

3.2.1 Decision Tree C4.5 Method Stage

The C4.5 Decision Tree calculation process is used to find the gain value of each of the criteria in the selection of scholarship recipients, in this case the KIP-Kuliah scholarship recipients. There are several stages in making a decision tree with the C4.5 algorithm [23]. in this case only looking up to the gain assessment, the following calculation is:

Preparing training data. The training data taken is from data that has occurred before or is called past data and has been grouped into certain classes. Below data on KIP-Kuliah scholarship recipients in 2020 can be seen in table 1.

Table 1. Decision on Determination of Scholarship Recipients from Management Study Program in 2020

Student	Parents' Income	Total Dependents	Interview Tests	Results
M1	1.250.001 - 1.500.000	7 People	75	ACCEPTED
M2	2.000.001 - 2.250.000	4 People	70	REJECTED
M3	3.750.001 - 4.000.000	1 People	71	REJECTED
M4	750.001 - 1.000.000	3 People	77	ACCEPTED
M5	1.750.001 - 2.000.000	2 People	73	REJECTED
M6	1.250.001 - 1.500.000	4 People	74	REJECTED
M7	3.750.001 - 4.000.000	2 People	78	REJECTED
M8	1.000.001 - 1.250.000	4 People	70	REJECTED
M9	2.750.001 - 3.000.000	3 People	73	REJECTED
M10	1.250.001 - 1.500.000	3 People	75	ACCEPTED
M11	2.250.001 - 2.500.000	1 People	80	ACCEPTED
M12	1.750.001 - 2.000.000	2 People	78	ACCEPTED

M13	2.250.001 - 2.500.000	3 People	77	ACCEPTED
M14	2.000.001 - 2.250.000	2 People	82	ACCEPTED
M15	1.750.001 - 2.000.000	2 People	77	ACCEPTED
M16	1.750.001 - 2.000.000	2 People	79	ACCEPTED
M17	2.750.001 - 3.000.000	3 People	78	ACCEPTED
M18	750.001 - 1.000.000	1 People	72	ACCEPTED
M19	1.750.001 - 2.000.000	4 People	75	ACCEPTED
M20	750.001 - 1.000.000	4 People	75	ACCEPTED
M21	1.250.001 - 1.500.000	3 People	72	ACCEPTED
M22	2.500.001 - 2.750.000	1 People	85	ACCEPTED
M23	3.750.001 - 4.000.000	1 People	80	REJECTED
M24	3.750.001 - 4.000.000	2 People	81	REJECTED

Table 1 is a sample data of 24 decision data for determining scholarship recipients taken from the 2021 KIP-Kuliah scholarship recipient data at the Academic and Student Affairs Bureau. The data will be used to design the C4.5 decision tree model and the results of the criteria gain will be used in finding the weight value in the Simple Additive Weighting (SAW) method. Based on the data in table 4.1, entropy and gain calculations are carried out to determine the root of the decision tree and the results of the gain per criterion are used to determine the weight.

Calculate the root of the tree. The root is taken from the selected attribute, by calculating the value of the gain of each attribute, the highest gain value will be the first root. Before calculating the gain value of the attribute, calculate the entropy value first. To calculate the entropy value can be seen in formula (1).

Entropy (S) $= \sum_{i=1}^{n} -pi\ log_2 pi$.....(1)

Description:

S = Set of Cases

n = Number of partitions S

Pi = proportion of Si to S Then calculate the gain value can be seen in formula (2).

Gain (S,A) = Entropy (s) - $\sum_{i=1}^{n} \frac{|S_i|}{|S|}\ Entropy(Si)$.....(2)

Description:

S = Set of cases

A = Features

n = Number of partitions of attribute A

|Si| = Proportion of Si to S

|S| = Number of cases in S

Below are the results of the calculation of entropy and gain for each attribute, can be seen in table 2.

Table 2. Entropy and Gain Calculation Results

DESCRIPTION	AMOUNT	ACCEPTED	REJECTED	ENTROPHY	GAIN
	24	15	9	0.954434003	
PARENTS' INCOME					0.5021526
Rp. 750.001 - Rp. 1.000.000	3	3	0	0	
Rp. 1.000.001 - Rp. 1.250.000	1	0	1	0	
Rp. 1.250.001 - Rp. 1.500.000	4	3	1	0.811278124	
Rp. 1.750.001 - Rp. 2.000.000	5	4	1	0.721928095	

Rp. 2.000.001 - Rp. 2.250.000	2	1	1	1	
Rp. 2.250.001 - Rp. 2.500.000	2	2	0	0	
Rp. 2.500.001 - Rp. 2.750.000	1	1	0	0	
Rp. 2.750.001 - Rp. 3.000.000	2	1	1	1	
Rp. 3.750.001 - Rp. 4.000.000	4	0	4	0	
NUMBER OF DEPENDENTS					0.1000074
1 People	5	3	2	0.970950594	
2 People	7	4	3	0.985228136	
3 People	6	5	1	0.650022422	
4 People	5	2	3	0.970950594	
5 People	0	0	0	0	
7 People	1	1	0	0	
INTERVIEW TESTS					0.7563137
70	2	0	2	0	
71	1	0	1	0	
72	2	2	0	0	
73	2	0	2	0	
74	1	0	1	0	
75	4	4	0	0	
77	3	3	0	0	
78	3	2	1	0.918295834	
79	1	1	0	0	
80	2	1	1	1	
81	1	0	1	0	
82	1	1	0	0	
85	1	1	0	0	

3.2.2 Simple Additive Weighting Method Steps

The Normalization formula can be seen in formula (3).

$$r_{ij} = \begin{cases} \dfrac{X_{ij}}{X_j^{max}} & \text{If j is a benefit attribute} \\ \dfrac{X_j^{min}}{X_{ij}} & \text{If j is a cost attribute} \end{cases} \quad (3)$$

where r_{ij} is the normalized performance rating of the alternative A_i on attributes C_j; i = 1, 2, ..., n Preference value for each alternative (V_i) can be seen in formula (4).

$$V_i = \sum_{j=1}^{n} w_j \, r_{ij} \quad (4)$$

Value (V_i) which is greater indicates that the alternative A_i is more selected. There are several stages of determining rankings using the SAW method as follows :

Determine the benefit (the higher the value, the better) or cost (the lower the value, the better) function for each attribute as shown in table 3.

Table 3. Criteria

No	*Criteria*	*Attribute*	*Weight*
C1	Parents' Income	Cost	0.5021526
C2	Parental Dependents	Benefit	0.1000074
C3	Interview Tests	Benefit	0.7563137

After determining the Benefit Function (+) and Cost Function (-) for each criterion as shown in table 4, the next step is to calculate the value of each Alternative in the Initial matrix, so that the Normalization Matrix is produced with the following conditions:

a. The Benefit (+) function is calculated by the formula of the value in the cell divided by the max value in the column.

b. The Cost (-) function is calculated by the MIN value formula in the column divided by the value in the Cell.

The next step is to calculate the value of each alternative by multiplying the results of the normalization matrix value on each alternative per criterion with the weight per criterion that has been generated from the decision tree method calculation process. The calculation results can be seen in Table 3.

Table 3. Alternative Data

Student	*C1*	*C2*	*C3*	*C1*	*C2*	*C3*
M1	Rp. 1.250.001 - Rp. 1.500.000	7 People	74	7	6	5
M2	Rp. 1.750.001 - Rp. 2.000.000	2 People	78	6	2	9
M3	Rp. 750.001 - Rp. 1.000.000	1 People	72	9	1	3
M4	Rp. 1.750.001 - Rp. 2.000.000	4 People	74	6	4	5
M5	Rp. 750.001 - Rp. 1.000.000	4 People	75	9	4	6
M6	Rp. 1.250.001 - Rp. 1.500.000	3 People	72	7	3	3
M7	Rp. 2.500.001 - Rp. 2.750.000	1 People	85	3	1	14
M8	Rp. 750.001 - Rp. 1.000.000	5 People	80	9	5	11
M9	Rp. 2.750.001 - Rp. 3.000.000	2 People	81	2	2	12
M10	Rp. 2.000.001 - Rp. 2.250.000	4 People	76	5	4	7
M11	Rp. 3.750.001 - Rp. 4.000.000	4 People	71	1	4	2
M12	Rp. 750.001 - Rp. 1.000.000	3 People	77	9	3	8
M13	Rp. 1.750.001 - Rp. 2.000.000	2 People	80	6	2	11
M14	Rp. 1.250.001 - Rp. 1.500.000	4 People	74	7	4	5
M15	Rp. 1.250.001 - Rp. 1.500.000	3 People	82	7	3	13
M16	Rp. 1.000.001 - Rp. 1.250.000	4 People	82	8	4	13
M17	Rp. 2.750.001 - Rp. 3.000.000	3 People	73	2	3	4
M18	Rp. 1.250.001 - Rp. 1.500.000	3 People	73	7	3	4
M19	Rp. 2.250.001 - Rp. 2.500.000	1 People	80	4	1	11
M20	Rp. 2.250.001 - Rp. 2.500.000	3 People	72	4	3	3

After calculating the value of each alternative, the next step is to determine the ranking of each alternative. In each alternative that has the largest value, it gets rank 1 and has the right to get the top priority to determine scholarship recipients. The ranking results can be seen in Table 4.

Table 4. Normalization

STUDENT	*C1*	*C2*	*C3*	*PREFERENCES*	*RANKING*

M1	0	1	2.80	2.29	9
M2	0	3	1.56	1.56	14
M3	0	6	4.67	4.19	2
M4	0	1.5	2.80	2.35	7
M5	0	1.5	2.33	1.97	10
M6	0	2	4.67	3.80	4
M7	0	6	1.00	1.52	15
M8	0	1.2	1.27	1.14	18
M9	1	3	1.17	1.43	16
M10	0	1.5	2.00	1.76	11
M11	1	1.5	7.00	5.95	1
M12	0	2	1.75	1.58	13
M13	0	3	1.27	1.35	17
M14	0	1.5	2.80	2.34	8
M15	0	2	1.08	1.09	19
M16	0	1.5	1.08	1.03	20
M17	1	2	3.50	3.10	5
M18	0	2	3.50	2.92	6
M19	0	6	1.27	1.69	12
M20	0	2	4.67	3.86	3

3.3 System Design

The design of the decision support system for KIP-Kuliah scholarship recipients can be done after the results of the analysis and calculation simulations have been carried out. The stages of system design that will be used in this research are system flowchart and logic prototype. The first form is a physical prototype that can show users how the proposed system can work physically. The following is a flowchart used in the design system in this study, can be seen in Figure 2.

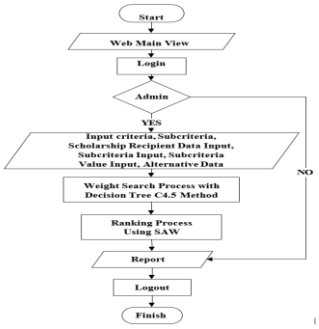


Figure 2. System Flowchart

3.4 Use Case Diagram

Use case diagram on this system has two actors, namely admin and leader, admin is an actor who has full power in terms of managing users, changing passwords, inputting alternative data, criteria data, inputting recipient data, inputting master results, preference value data and selection results. While the leader actor only sees the selection result report and can print the ranking results. Both actors before entering the system must access login and when exiting the system can end it through logout. Use Case Diagram can be seen in Figure 3.

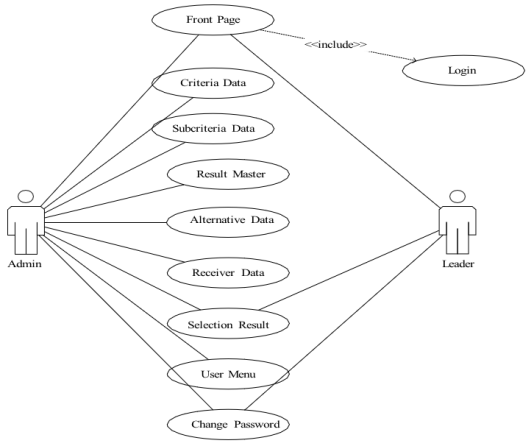


Figure 3. Use Case Diagram of the System as a Whole

The following explanation of the use case can be seen in table 5.

Table 5. Use Case Diagram of the System as a Whole

Use Case Name	*Description*	*Actor*
Login	Provides information about events where the admin and selection team can log in as application users and the selection process.	Admin/Leader
Data input	Describes the event where the admin can input criteria data, sub-criteria data, input scholarship recipient data.	Admin
Report	Describes the event where the leader gets the selection results that have been inputted by the admin.	Admin/Leader

3.5 Class Diagram

Class diagram describes the relationship between classes and a detailed explanation of the classes in the design model and a system for each class diagram on the decision-making system. The class diagram image can be seen in Figure 4.

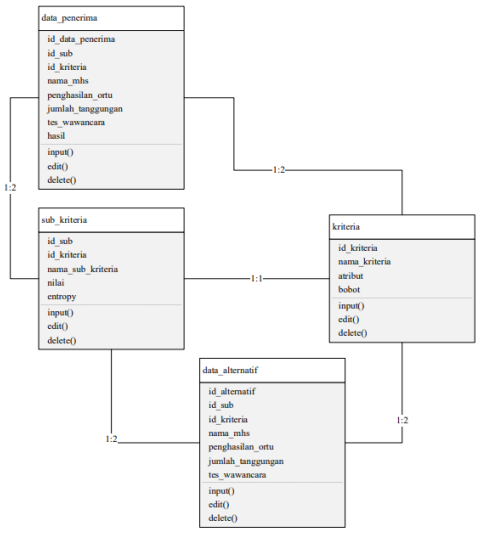


Figure 4. Activity Diagram

3.7 System Model

The system model describes the appearance of the system design that has been designed previously. The goal is to show the feasibility of the system design at the implementation stage. Therefore, the system prototype is also a display in the form of a program that is run in accordance with the system being developed. The following schemes can be seen in Figure 5.

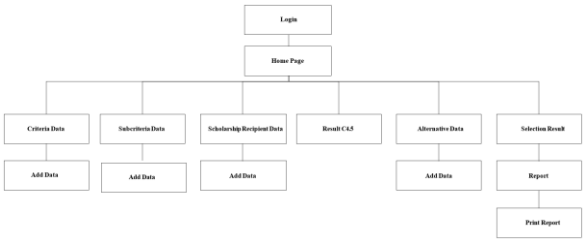


Figure 5. Menu Scheme of Decision Support System

Next are the results of the prototype made in accordance with the scheme and system design that has been made, the following explanation is presented visually:

1. Login Display

On the login page display there are two text forms, namely username and password, both of which function to enter this system, namely by entering the username and password then clicking the login button, the login display can be seen in Figure 6.

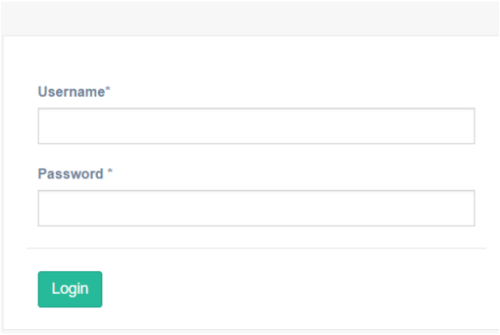


Figure 6. Login view

2. Main Page Display

After the user logs in, the next step is to enter the main page. On the main page display there are several menus that are used for inputting criteria data, inputting sub-criteria data, inputting alternative data, inputting recipient data and selection results. The main page display can be seen in Figure 7.

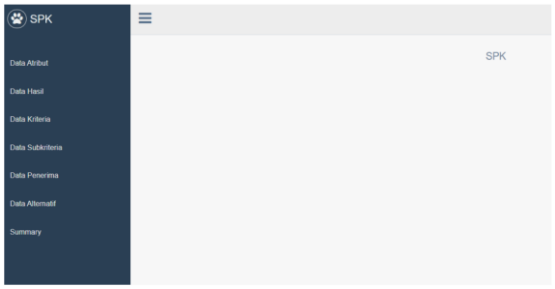


Figure 7. Main Page Display

3. Criteria Menu Display

In the criteria data menu display, the user fills in the criteria code, criteria name, attributes containing cost or benefit, weight. The criteria menu display can be seen in Figure 8.

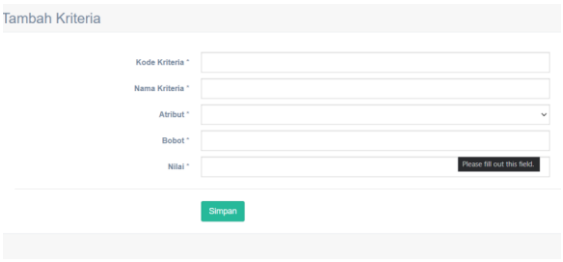


Figure 8. Criteria Menu

4. Subcriteria Data Menu Display

After the criteria master data, the next step is to input subcriteria data. The initial text box selects criteria, then fills in the subcriteria, fills in the name of the subcriteria, then fills in the value for each subcriteria. The display of the subcriteria menu can be seen in Figure 9.

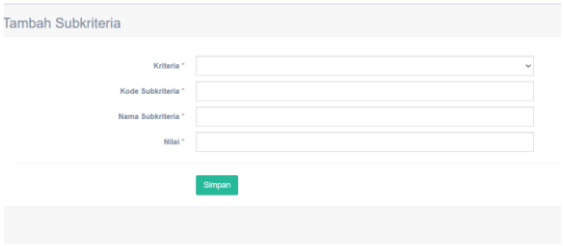


Figure 9. Subcriteria Menu

5. Recipient Data Display

The next stage is to fill in the recipient data in the previous year, this menu is used to find the weight value. Furthermore, fill in the form of student names, parents' income, parents' dependents, interview tests and results accepted or rejected. The recipient data display can be seen in Figure 10.

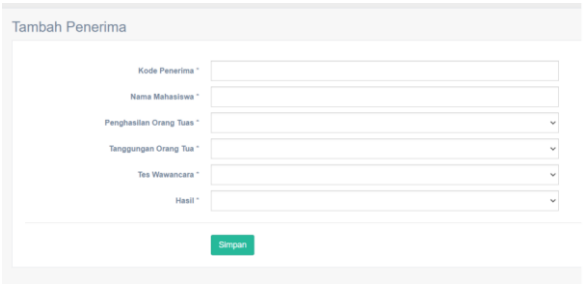


Figure 10. KIP-Kuliah receiver Data Display

6. Alternative Data Display

After the criteria, sub-criteria and criteria weights have been obtained, the next step is to fill in alternative data to determine the ranking of scholarship recipients. The form contains input of student names, parental dependents, interview tests. Alternative data display can be seen in Figure 11.

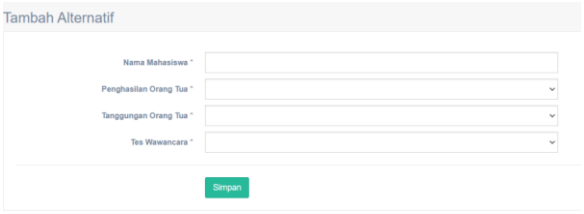
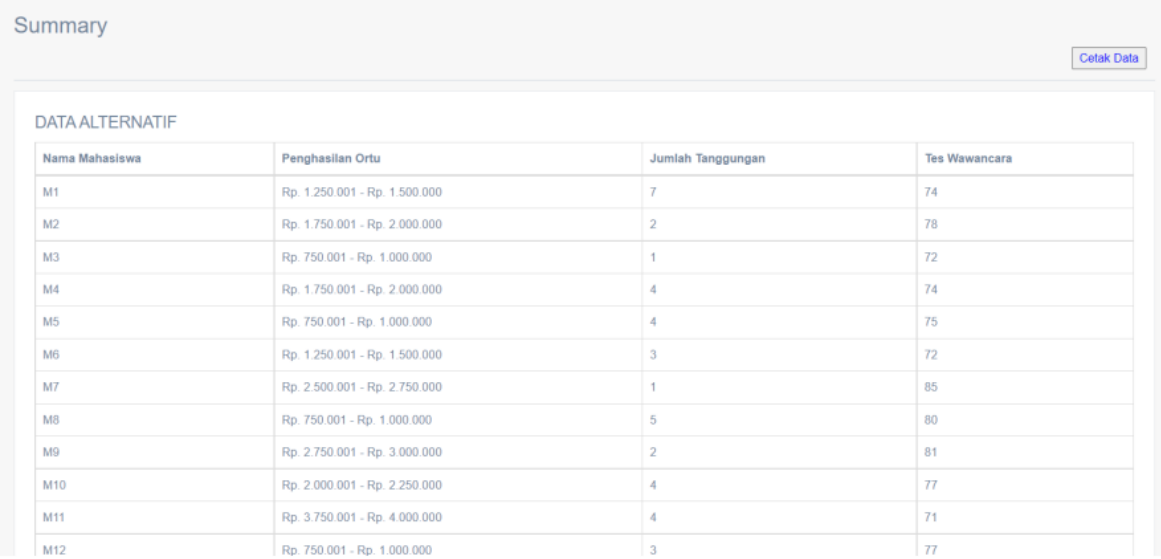


Figure 11 Alternative Data Menu

7. Selection Page Display

The next stage is the calculation on the selection page menu, on this menu you can see the results of the calculation and can see the ranking of scholarship recipients. The selection page display can be seen in Figure 12.



Nama Mahasiswa	Penghasilan Ortu	Jumlah Tanggungan	Tes Wawancara
M1	Rp. 1.250.001 - Rp. 1.500.000	7	74
M2	Rp. 1.750.001 - Rp. 2.000.000	2	78
M3	Rp. 750.001 - Rp. 1.000.000	1	72
M4	Rp. 1.750.001 - Rp. 2.000.000	4	74
M5	Rp. 750.001 - Rp. 1.000.000	4	75
M6	Rp. 1.250.001 - Rp. 1.500.000	3	72
M7	Rp. 2.500.001 - Rp. 2.750.000	1	85
M8	Rp. 750.001 - Rp. 1.000.000	5	80
M9	Rp. 2.750.001 - Rp. 3.000.000	2	81
M10	Rp. 2.000.001 - Rp. 2.250.000	4	77
M11	Rp. 3.750.001 - Rp. 4.000.000	4	71
M12	Rp. 750.001 - Rp. 1.000.000	3	77

Figure 12. Selection Page Display Menu

8. Report Display

After the calculation results are obtained, the next step is to view the ranking results report. The report results can be printed immediately. The report display can be seen in Figure 13.

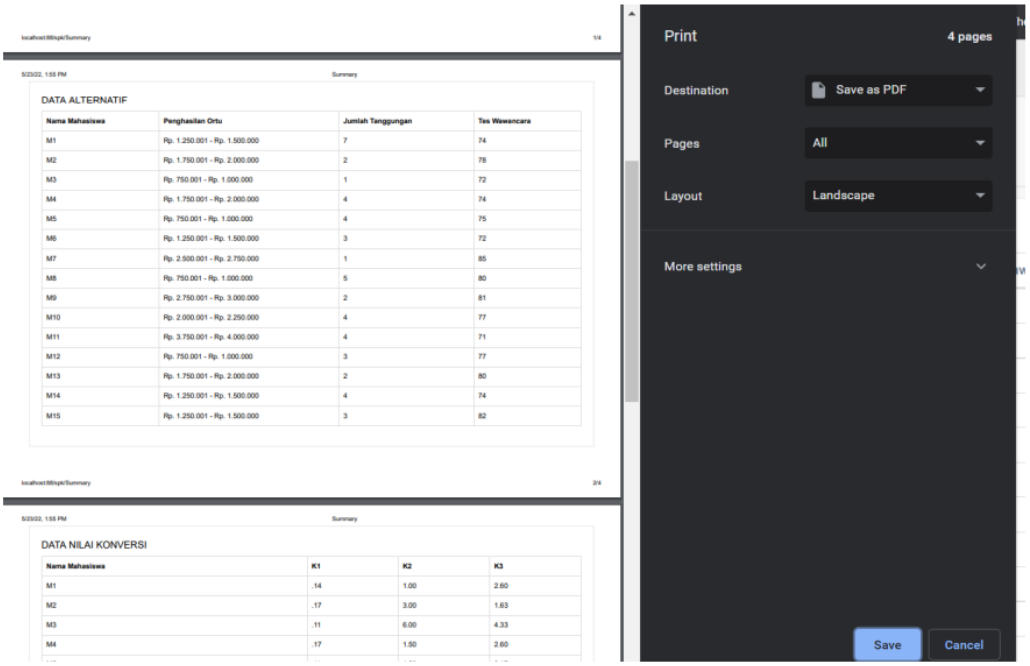


Figure 13. Print Scholarship Recipient Results

4. Conclusion

Based on the analysis, research objectives and data processing carried out in this study, the authors draw the following conclusions, The results of the analysis of the calculation using the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods and the results of the selection of college KIP-Kuliah scholarships consisting of the criteria for the amount of parents' income, the number of dependents and the interview test, then the 12 students who deserve college KIP scholarships are students who get the highest preference value, namely M11, M3, M6, M4, M14, M1, M5, M12, M10, M2, M7, M9. Decision support system application that uses Decision Tree C4.5 and Simple Additive Weighting (SAW) methods to facilitate decision making on the selection of scholarship recipients. The process of determining the ranking of scholarship recipient selection applied using the Decision Tree C4.5 and Simple Additive Weighting (SAW) methods, starting with the weighting of criteria up to the calculation and grouping of core and

secondary factors, calculation of the total value and then there is a calculation of ranking determination.

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