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Application of Simple Additive Weighting Method for Decision Making for Scholarship Recipients at SMA Angkasa Adisutjipto Yogyakarta

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ABSTRACT

The SMA Angkasa Adisucipto Yogyakarta scholarship selection process requires an effective and objective approach to ensure that scholarships are awarded to students who meet the relevant criteria. The purpose of this study is to apply the Simple Weighting (SAW) method as a decision support in selecting scholarship recipients. The SAW technique was chosen because it allows for weighting calculations, allowing for a more systematic analysis of the criteria. The criteria used include student academic performance, attendance, behavior, and financial situation, each of which is weighted according to its importance. Eligible student data is processed using the SAW method to determine the final preference score, which is then used to rank prospective scholarship recipients. The results of the study indicate that the SAW method can make accurate and transparent decisions in selecting scholarship recipients. The application of the SAW method not only increases the efficiency of selection, but also reduces the subjectivity that occurs in the evaluation. In summary, the SAW method is very suitable as a decision-making tool based on various criteria, especially in selecting grant recipients.

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1. INTRODUCTION

To produce competitive and quality human resources, education plays an important role as a foundation for improving individual and community capabilities [1], [2]. In Indonesia, scholarships are often provided as a form of educational support to support students who meet certain criteria both in terms of academic achievement and poor economic conditions [1], [3]. Scholarships not only provide financial benefits, but also play an important role in motivating students to achieve higher levels, reducing dropout rates, and improving the quality of education at the individual and organizational levels. SMA Angkasa Adisutjipto Yogyakarta is one of the educational institutions that actively provides scholarships to its outstanding students. This scholarship is provided to help outstanding students maintain and improve their academic achievement, and to help students with financial constraints so as not to burden themselves with educational costs[4], [5]. However, when selecting scholarship recipients, the challenge is often whether the scholarship is truly given objectively and fairly to students who meet the criteria.

The main criteria in selecting SMA Angkasa Adisucipto scholarship recipients include students' academic achievement, attendance, behavior, and financial situation. The main challenge in this selection is to combine these criteria systematically, because each criterion has a different meaning. Without a structured

approach, scholarship evaluation will be prone to bias and subjectivity, which can lead to unfairness in the selection process. The lack of an objective and measurable selection method can also lead to dissatisfaction among students and parents. In this context, the use of a decision-making method based on various criteria is very important. The selection of the right method in multicriteria decision making greatly affects the accuracy and efficiency of the results. Several frequently used methods, such as Analytic Hierarchy Process (AHP), Weighted Product Model (WPM), and Simple Additive Weighting (SAW), have their own characteristics and advantages. However, SAW is often more effective in many cases because of its advantages in handling simple and direct data [6], [7], [8], [9]. One method that can be used is Simple Additive Weighting (SAW) [10], [11], [12]. It is known to be effective and efficient in providing scores based on weight for each criterion. The SAW technique assigns weight to each criterion according to its importance and accumulates the value for each criterion that meets certain criteria [13], [14]. Through this approach, the SAW methodology helps develop final priorities that form the basis for decision-making in peer selection.

The use of the SAW methodology in the selection of grant recipients provides several benefits, including increasing objectivity, transparency, and consistency of evaluation [13], [15], [16], [17], [18]. This method makes the evaluation process more structured and allows decision makers to evaluate students based on systematic and transparent calculations. The SAW methodology, on the other hand, allows each criterion to be designed to suit the school's priorities, such as placing more emphasis on academic performance or economic status. The purpose of this study is to introduce the SAW method to the SMA Angkasa Adisucipto Yogyakarta scholarship selection process, so that the evaluation process can be carried out more accurately, fairly, and efficiently. The use of the SAW methodology allows the selection of prospective scholars to be carried out optimally, reduces the risk of errors and bias in the evaluation, and ultimately increases the trust of students, parents, and school staff in the selection process.

2. RESEARCH METHOD

This study aims to apply the Simple Additive Weighting (SAW) technique to the selection process of SMA Angkasa Adisutjipto Yogyakarta students. This research method involves several stages: data collection, determination of criteria and weights, application of the SAW method, and evaluation of results. Each phase is intended to support the correct application of the SAW method and produce accurate and objective decisions. The following methodological steps are used in this study:

2.1. Data Collection

Data was taken in 2022, the population in this study were prospective high school students receiving scholarships. The sample in this study were several students who registered to seek scholarships at SMA Angkasa. The method of determining the sample is in the form of a random sample of several students who registered to seek scholarships. The first stage in this research is the collection of relevant data related to prospective scholarship recipients. The data collected includes:

1. Academic Data: Students' average academic grades, as an indicator of academic achievement.
2. Attendance: Student attendance data during a certain period as an indicator of discipline and commitment to learning.
3. Behavior: Assessment of student behavior, which can be taken from teacher or counselor records.
4. Economic Condition: Information on the economic status of the student's family, obtained from supporting documents such as a certificate of poverty.

Data is collected from various sources at school, including academic records, administrative data, and interviews if necessary to complete the information. All data collected is then arranged in a format suitable for processing using the SAW method.

2.2. Determination of Criteria and Weights

The main criteria used in the selection of scholarship recipients are academic achievement, attendance, behavior, and economic conditions of students. Each criterion is given a weight according to its level of importance. The determination of the weight is done through discussion and consultation with relevant parties in the school, such as the principal, teachers, and administrative staff, to ensure that the weight reflects the school's priorities in awarding scholarships. The weight is given in a certain range, for example between 0 and 1, with the total weight of all criteria being 1. This weighting allows more important criteria, such as economic conditions, to have a greater influence on the final assessment.

2.3. Simple Additive Weighting (SAW)

After the histogram of the image data is obtained, the following process is to compare the histogram values SAW works by summing the performance values of each alternative on all criteria after the values are

normalized. This method is often used because of its ease of implementation and ability to handle data at various scales. SAW has the following stages:

1. Identifying Criteria and Alternatives
   a. Determine the alternatives to be evaluated.
   b. Determine the relevant criteria for the decision-making process, along with the weight (W) for each criterion.

2. Deciding Matrix: The decision matrix (X) is made based on the performance value of each alternative on each criterion (shown in Formula (1))

$$X = [X_{IJ}] \qquad (1)$$

   where:
   X_{IJ} is the performance value of the ith alternative on the jth criterion

3. Decision Matrix Normalization
   The normalization matrix (R) is used to equalize the values of different criteria. Normalization is done using the formula:
   For benefit criteria in Formula (2)

$$r_{ij} = \frac{X_{IJ}}{\max(X_{IJ})} \qquad (2)$$

   Where max (xij) is the maximum value of the jth criterion

   For cost criteria in Formula (3).

$$r_{ij} = \frac{X_{IJ}}{\min(X_{IJ})} \qquad (3)$$

   Where min (X_{IJ}) is the minimum value of the jth criterion

4. Calculation of Final Value (Ranking)
   After the matrix is normalized, the final value (V) for each alternative is calculated by summing the results of multiplying the normalized value by the weight of each criterion in Formula (4).

$$\text{Vi} = \sum_{j=1}^{n} w_J \,.\, r_{IJ} \qquad (4)$$

   Where:
   Vi = final value for the i-th alternative
   w_J = weight for the j-th criterion
   r_{IJ} = normalized value for the i-th alternative on the j-th criterion
   n = number of criteria

5. Ranking Determination: The alternative with the highest V_i value is considered the best alternative. The alternative with the highest Vi value is considered the best alternative.

2.4. Flowchart Systems

Based on Figure 1, the proposed scholarship recipient decision-making use case diagram contains:
1. One system includes the activities of the scholarship recipient decision-making support system.
2. There are two actors who carry out activities in the system.
3. 10 use cases that can be done by the admin.
4. 10 use cases that can be done by the principal.
5. Include criteria data that can be done by the admin and principal, namely add data, edit data and delete data.
6. Include sub-criteria data that can be done by the admin and principal, namely add data, edit data and delete data.
7. Include alternative data that can be done by the admin and principal, namely edit data.

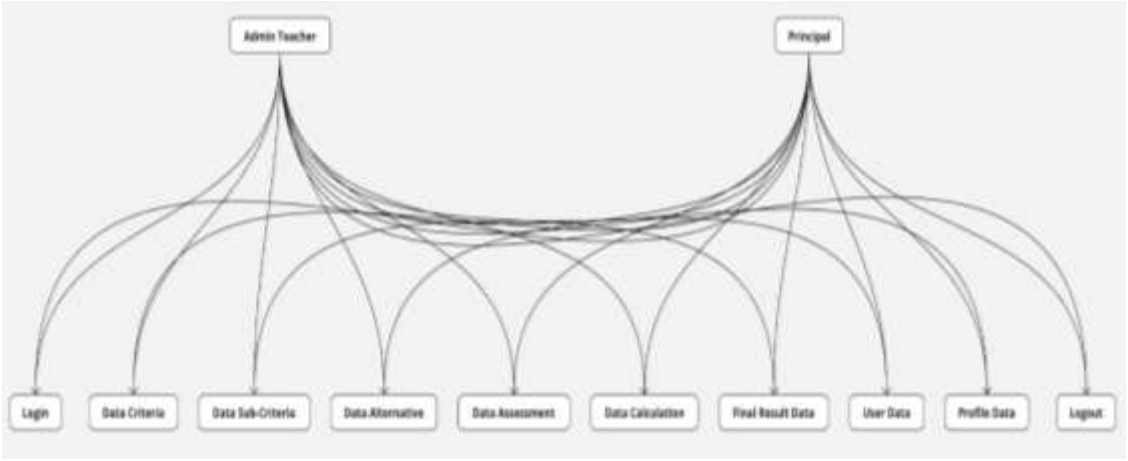

Figure 1. Flowchart System

Figure 2 shows a flowchart for the login process on a system. The following is an explanation of the steps described in the flowchart:

1. Start: The process begins.
2. Enter Username: The user is prompted to enter a username.
3. Enter Password: After entering the username, the user is prompted to enter a password.
4. Click Login Button: The user presses the login button to continue the verification process.
5. Validate Credentials: The system validates the entered credentials (username and password).
6. Credentials Valid: The system checks whether the entered credentials are valid.
7. Yes (Valid): If the credentials are valid, access is granted.
8. No (Invalid): If the credentials are invalid, access is denied, and the user is prompted to try again.
9. Access Granted: If the credentials are valid, the user is granted access.
10. Access Denied - Retry: If the credentials are invalid, access is denied, and the user is prompted to try again.

This diagram illustrates a common login flow used to ensure that only users with valid credentials can access the system.

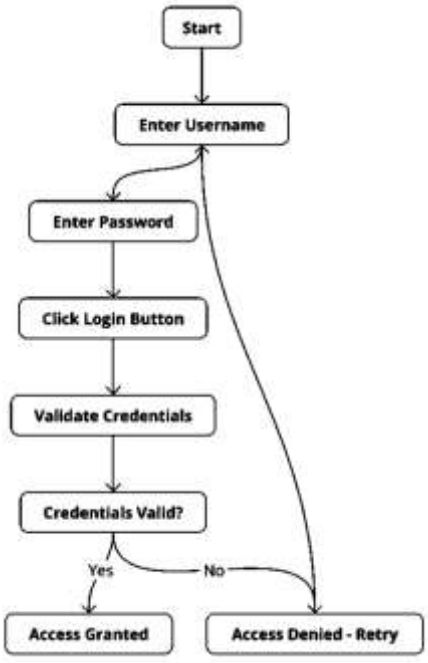

Figure 2. Activity System

3. RESULTS AND DISCUSSION

3.1. Decision Support System Calculation

This stage is the testing stage of the system that has been created, this testing is carried out using the Black Box Testing method. This testing includes input, process, and output activities.

1. Determining each criterion is shown in Table 1.

Table 1 defines the codes for each criterion used in the decision-making system. K1 - Parent's Income is used to measure the economic condition of the prospective recipient's family. K2 - Average Value is used to measure the student's academic achievement. K3 - Number of Siblings reflects the family's economic burden. Criterion K4 is used to assess the level of student discipline, which is often categorized on a letter scale (eg: A, B, C, D). and Criterion K5 evaluates student participation in extracurricular activities at school.

Table 1. Criteria Terms

Code	Criteria
K1	Parent's Income
K2	Average Value
K3	Number of siblings
K4	Discipline
K5	Extracurricular

2. Table 2 is giving a weight value for each criterion.

Table 2 defines the criteria along with the weight values and optimization directions (weight criteria) used in decision-making calculations.

Table 2. Weight of Each Criteria

Criteria	Weight value	Weight Criteria
K1	3	Min
K2	2,5	Max
K3	2	Max
K4	1,5	Max
K5	1	Max

3. Suitability Rating Tableis shown in Table 3.

Table 3 contains assessment information from several criteria (K1 to K5) for each name of the prospective scholarship recipient.

Tabel 3. Compatibility Rating

	Criteria				
Name	K1	K2	K3	K4	K5
Adinda Diah Apriyanti	500,000 - 999,999	80.12	0	A	80
Ananda Andriyansyah	1,000,000- 1,999,999	78.82	3	A	78
Fitriyaningsih	500,000 - 999,999	82.11	4	A	78
Andin Afriani	1,000,000- 1,999,999	80.38	2	A	75
Kevin Dwi Fernanda	1,000,000-1,999,999	78.53	0	A	85
Hugo Wijdan Rajendra	1,000,000-1,999,999	77.36	2	C	65
Yoga Prima Aditama	1,000,000-1,999,999	77.82	3	A	60
Yohanes Herang AjiDharma	1,000,000-1,999,999	79.37	2	B	76
Yohanis Babtista Tutuboy	1,000,000-1,999,999	78.88	4	B	80
Muhammad Brahma Panca Buana	1,000,000-1,999,999	78.88	3	A	65
Rosmila Apia Warami	1,000,000-1,999,999	76.06	4	D	65
Setya Priya Adinugraha	1,000,000-1,999,999	78.37	3	B	65
Uswatun Khasanah	1,000,000-1,999,999	79.42	1	A	76
Anisa Nuri Rahmawati	500,000 -999,999	79.28	2	B	65
Ditantri Prahesti Ayu	500,000 -999,999	79.19	1	B	68

4. Parental incomeis shown in Table 4.

Table 4 is used to provide an assessment or score of parental income grouped into several specific value ranges. This criterion is usually used in decision support systems, such as scholarship acceptance, where parental income is one of the important factors in determining the eligibility of prospective recipients.

Tabel 4. Parental Income Value

Parent's Income (K1)	Value
1.000.000 – 2.999.999	5
501.000 – 999.999	4
99.000 – 500.000	3

5. Average Value is shown in Table 5.

Table 5 contains the conversion of Average Value into Value (Score) used as part of the evaluation in the decision-making system, playing an important role in converting students' academic grades into more structured scores that can be used in the calculation of the decision-making system, such as the SAW method. The highest grade is given to students with the best Average Value, which indicates superior academic achievement.

Table 5. Average Value

Average Value (K2)	Value
100	8,1
99,50	8,0
99	7,9
98,50	7,8
98	7,7
97,50	7,6
97	7,5
96,50	7,4
96	7,3
95,50	7,2
95	7,1
94,50	7,0
94	6,9
93,50	6,8
93	6,7

6. Number of Siblings is shown in Tabel 6.

Table 6 provides the conversion of values based on the number of siblings of the student. This value is used as one of the criteria (K3) in the decision support system.

Table 6. Number of Siblings

Number of siblings (K3)	Value
0	1
1	1
2	2
3	3
≥ 4	4

7. Discipline is shown in Table 7.

Table 7 defines the conversion of student discipline values (K4) into scores. These values are used as part of the criteria in decision support systems, such as the selection of scholarship recipients.

Tabel 7. Discipline

Discipline (K4)	Value
A	1
B	2
C	3
D	4
E	5

8. Extracurricular is shown in Table 8.

Table 8 shows the conversion of extracurricular activity values (K5) into scores used in decision-making systems, such as the selection of scholarship recipients.

Table 8. Extracurricular

Extracurricular (K5)	Value
100	5
99	4,9
98	4,8
97	4,7
96	4,6
95	4,5
94	4,4
93	4,3
92	4,2
91	4,1
90	4
89	3,9
88	3,8
87	3,7
86	3,6
85	3,5
84	3,4
83	3,3
82	3,2
81	3,1
80	3

9. Weight Data is shown in Table 9.

Table 9 is used to calculate the final score using the Simple Additive Weighting (SAW) method. Each criterion will be normalized according to the optimization direction (Min or Max) and multiplied by the weight of each criterion to produce the final ranking of scholarship candidates.

Table 9. Weight Data

Name	Criteria				
	K1	K2	K3	K4	K5
Adinda Diah Apriyanti	4	4,1	1	5	3
Ananda Andriyansyah	5	3,8	3	5	2,8
Fitriyaningsih	4	4,5	4	5	2,8
Andin Afriani	5	4,1	2	5	2,5

Kevin Dwi Fernanda	5	3,8	1	5	3,5
Hugo Wijdan Rajendra	5	3,5	2	3	1,5
Yoga Prima Aditama	5	3,6	3	5	1
Yohanes Herang Aji Dharma	5	3,9	2	4	2,6
Yohanis Babtista Tutuboy	5	3,8	4	4	3
Muhammad Brahma Panca Buana	5	3,8	3	5	1,5
Rosmila Apia Warami	5	3,3	4	2	1,5
Setya Priya Adinugraha	5	3,7	3	4	1,5
Uswatun Khasanah	5	3,9	1	5	2,6
Anisa Nuri Rahmawati	4	3,9	2	4	1,5
Ditantri Prahesti Ayu	4	3,9	1	4	1,8

10. Table 10 shows the Matrix Normalization. Create a matrix equation based on an equation that is adjusted to the attribute type (profit attribute or cost attribute).

Table 10. Determining Benefit or Cost

Criteria	Benefit	Cost
Parent's Income	-	□
Average Value	□	-
Number of siblings	□	-
Discipline	□	-
Extracurricular	□	-

For the criteria of parents' income is shown Eq. 2 dan Eq. 3.

$$Ri1 = \frac{3}{4} = 0,75$$

$$Ri2 = \frac{3}{5} = 0,6$$

$$Ri3 = \frac{3}{4} = 0,75$$

For the average value criteria, Eq. 2 dan Eq. 3 is shown.

$$Ri1 = \frac{4,1}{5,1} = 0,8$$

$$Ri2 = \frac{3,8}{5,1} = 0,75$$

$$Ri3 = \frac{4,5}{5,1} = 0,88$$

The criteria for the number of siblings are shown in Eq. 2 dan Eq. 3.

$$Ri1 = \frac{1}{4} = 0,25$$

$$Ri2 = \frac{3}{4} = 0,75$$

$$Ri3 = \frac{4}{4} = 1$$

The criteria for discipline are shown in Eq. 2 dan Eq. 3.

$$Ri1 = \frac{5}{5} = 1$$

$$Ri2 = \frac{5}{5} = 1$$

$$Ri3 = \frac{5}{5} = 1$$

For extracurricular criteria shown in Eq. 2 dan Eq. 3.

$$R11 = \frac{3}{4,5} = 0,67$$

$$R12 = \frac{2,8}{4,5} = 0,62$$

$$R13 = \frac{2,8}{4,5} = 0,62$$

Table 11 is created, namely the normalized matrix.

Table 11. Normalized Matrix

Name	Criteria				
	K1	K2	K3	K4	K5
Adinda Diah Apriyanti	0,75	0,8	0,25	1	0,67
Ananda Andriyansyah	0,6	0,75	0,75	1	0,62
Fitriyaningsih	0,75	0,88	1	1	0,62
Andin Afriani	0,6	0,8	0,5	1	0,56
Kevin Dwi Fernanda	0,6	0,75	0,25	1	0,78
Hugo Wijdan Rajendra	0,6	0,69	0,5	0,6	0,33
Yoga Prima Aditama	0,6	0,71	0,75	1	0,22
Yohanes Herang Aji Dharma	0,6	0,76	0,5	0,8	0,58
Yohanis Babtista Tutuboy	0,6	0,75	1	0,8	0,67
Muhammad Brahma Panca Buana	0,6	0,75	0,75	1	0,33
Rosmila Apia Warami	0,6	0,65	1	0,4	0,33
Setya Priya Adinugraha	0,6	0,73	0,75	0,8	0,33
Uswatun Khasanah	0,6	0,76	0,25	1	0,58
Anisa Nuri Rahmawati	0,75	0,76	0,5	0,8	0,33
Ditantri Prahesti Ayu	0,75	0,76	0,25	0,8	0,4

The results obtained are as follows:

V1 = (3*0,75) + (2,5*0,8) + (2*0,25) + (1,5*1) + (1*0,67) = 6,92
V2 = (3*0,6) + (2,5*0,88) + (2*0,75) + (1,5*1) + (1*0,62) = 7,295
V3 = (3*0,75) + (2,5*0,88) + (2*1) + (1,5*1) + (1*0,62) = 8,57

From the results of the weighted matrix above, the ranking can be done, the results of which are shown in Table 12.

Table 12. Formula Vi Results

No	Name	Value of Vi	Ranking
1	Adinda Diah Apriyanti	6,92	20
2	Ananda Andriyansyah	7,295	13
3	Fitriyaningsih	8,57	1
4	Andin Afriani	6,86	22
5	Kevin Dwi Fernanda	6,455	30
6	Hugo Wijdan Rajendra	5,755	42
7	Yoga Prima Aditama	6,795	23
8	Yohanes Herang Aji Dharma	6,48	29
9	Yohanis Babtista Tutuboy	7,545	8
10	Muhammad Brahma Panca Buana	7,005	17
11	Rosmila Apia Warami	6,355	32
12	Setya Priya Adinugraha	6,655	27
13	Uswatun Khasanah	6,28	33
14	Anisa Nuri Rahmawati	6,68	26
15	Ditantri Prahesti Ayu	6,25	34

Based on the ranking process in Table 12, it is concluded that the priority of scholarship recipients can be seen in the results in Table 13.

Table 13. Ranking Results

No	Name	Value of Vi	Ranking
1	Fitriyaningsih	8,57	1
2	Afrah Inayati	8,5	2
3	Muhammad Zakky AinurRidho	8,44	3
4	Ananda Wulandari	8,33	4
5	Wildan Imam Saputra	8,19	5
6	Septi Susilowati	8,04	6
7	Monica Biyant Balqis	7,99	7
8	Yohanis Babtista Tutuboy	7,545	8
9	Rizal Aldy Saputra	7,54	9
10	Aima Izza Nugroho	7,36	10
11	Dimas Tio Ananda Trawiten	7,33	11
12	Wisnu Aji Trisnawan Sudarmo	7,32	12
13	Ananda Andriyansyah	7,295	13
14	M. Qomarudin Wahid Cakraningrat	7,29	14
15	Muhammad Syaddad Alfaruq	7,14	15

3.2. System Testing

This stage is the testing stage of the system that has been created, this testing is carried out using the Black Box Testing method. This testing includes input, process, and output activities. Black box testing aims to determine whether the system that has been created is in accordance with the expected specifications. The overall test results are shown in Table 14.

Table 14. Black Box System Testing

Cases and Test Results (Normal Data)			
Input data	Expected	Observation	Information
Username: Admin *Password*: Admin	Admin is listed in the username and password text	Admin is listed in the username text and ***** is listed in the password text	success
Click the login button	User data will be searched in the user table in the database and entered into the main page.	The login button can function as expected	success
Fill in the criteria code	Displaying criteria data	Displays criteria data according to expected code	success
Click the edit button	Change data is in the saved table	Data changes in the table are saved	success
Click the cancel button	Data not saved and return to criteria page	Data not saved and return to criteria page	success

Fill in the assessment code	Displays data according to expected code	Displays assessment data according to expected code	success
Fill in the calculation code	Displays data according to expected code	Displays calculation data according to the expected code	success
Fill in the final result code	Displays data according to expected code	Displays the final result data according to the expected code.	success

This scholarship recipient decision support system is designed to simplify the recipient selection process by providing a variety of comprehensive data management features. This system is expected to increase efficiency and accuracy in selecting the right scholarship recipients, by utilizing target data that can be accessed and managed by admins and principals. The implementation of this system also supports increased transparency and quality of decision making in awarding scholarships, the SAW method has proven effective for use in building decision support systems [19], [20], [21], [22], [23], [24], [25]. The test results show that SAW is a more effective choice in situations where decisions must be made quickly and accurately. In addition, SAW is very suitable for problems with simple data structures, making it more practical than AHP and WPM which require additional steps in data processing.

4. CONCLUSION

Based on the results of the tests that have been carried out. This study produces a decision support system for accepting scholarships that can be accepted by SMA Angkasa Adisutjipto Yogyakarta, using the SAW method with 5 (five) criteria used, namely parental income, average grades, number of siblings, discipline and extracurricular activities. From the system calculation test, the highest value output and first ranking were produced, students who are entitled to receive the SMA Angkasa Adisutjipto Yogyakarta scholarship are Fitriyaningsih with a value of (8.57) and get the first ranking (1). Referring to the results of the tests that have been carried out, this study has succeeded in producing a scholarship acceptance decision support system designed to meet the needs of SMA Angkasa Adisutjipto Yogyakarta. This study not only shows that the SAW method is effective in solving multi-criteria decision-making problems, but also provides real solutions that can be applied directly in educational environments. With this system, it is hoped that the scholarship selection process will be more objective, transparent, and fair, thus supporting the school's goal of awarding students who meet the criteria more efficiently.

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