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Decision Support Systems the Selection of Outstanding Students Using Simple Additive Weighting (SAW) and Weighted Product (WP) Methods

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Abstract

Appreciation for outstanding students is one of the encouragement for students to continue to maintain and improve their achievements. Generally, the selection of outstanding students in every school still uses the report value as the reference. Currently the selection of outstanding students at SMP Strada Santa Maria 2 still using the report card value (academic) as a reference. In addition, the school does not have a system that helps the selection and processing process based on several criteria considered. Therefore a decision support system is needed in order to help overcome problems and accelerate the selection of outstanding students. In this decision support system uses the SAW method (Simple Additive Weighting) and WP (Weighted Product) and compares the two methods. The criteria used included the value of the average semester 1, the value of the average semester 2, the value of attitudes, absences, and activeness of extracurricular activities. The results of these calculation in the form of the final value of each method and form of ranking that will be recommended to assist the school in determining the outstanding students according to the required criteria. Based on the terms of execution time, the SAW method is slightly faster than the WP method and and in terms of the test results using RSD, the value generated from the WP method calculation is better than the value generated from the SAW method calculation, where the RSD value of the WP method is 14.74% and SAW is 10.46%.

I. INTRODUCTION

Appreciation for outstanding students is one of the encouragement for students to continue to maintain and improve their achievements. Appreciation for students who excel can also make other students motivated to increase the spirit of learning in all circles to achieve even better performance [1].

Generally, the selection of outstanding students in every school still uses the report value as the reference. The value of students will be ranked in parallel and those who occupy positions 1 to 3 will be selected as outstanding students and recommended to get a scholarship [2].

Currently the selection of outstanding students at SMP Strada Santa Maria 2 still using the report card value (academic) as a reference. In addition, the school does not have a system that helps the selection and processing process based on several criteria considered due to outstanding students in the electoral process requires precision and time-consuming if done manually, in which every student data will be compared and counted one by one in accordance with the criteria set to become outstanding students.

Based on these problems will require a decision support system for selecting outstanding students to help make decisions based on the criteria that have been determined and the results obtained under the criteria that have been established and are objective.

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Where this system using SAW (Simple Additive weighting) and WP (Weighted Product) method. This method is used because it can determine the weight value for each attribute, then proceed with a ranking the process that will select the best alternative from some alternatives based on the specified criteria [3].

The purpose of this research are to compare the Simple Additive Weighting (SAW) and Weighted Product (WP) methods in the selection of outstanding students, applying the Simple Additive Weighting (SAW) method and the Weighted Product (WP) method in designing a system that is easy to use and can help parties SMP Strada Santa Maria 2 for the selection of outstanding students, and provides recommendations that can assist in the decision making of the selection of high achieving students to selected schools objectively and according to the criteria determined based on the results of both methods namely Simple Additive Weighting (SAW) and Weighted Product method (WP).

II. Related Works/Literature Review (Optional)

DSS, and Learning Achievement

Decision Support System (DSS) is a computer-based interactive application that combines data and mathematical models to help the decision making process in handling a problem [4].

Learning achievement is the result of the measurement of the assessment of learning efforts expressed in the form of symbols, letters, and sentences that describe the results that have been achieved by each child in a certain period [5].

Definition of SAW Method

Simple Additive Weighting (SAW) method is often also known as the weighted addition method. The basic concept of the SAW method is to find a weighted sum of performance branches on each alternative on all attributes. The SAW method requires the normalization of the decision matrix (X) to a scale that can be compared with all available alternative branches [3].

Definition of WP Method

Weighted Product (WP) method is one of the settlement methods offered to solve the Multi-Attribute Decision Making (MADM) problem. The Weighted Product method is similar to the Weighting Sum (WS) method, only the Weighted Product (WP) method has multiplication in its mathematical calculations.

The Weighted Product method is also called dimensional analysis because the mathematical structure removes the unit of measurement. The Weighted Product (WP) method uses multiplication to connect the attribute rating, where the rating of each attribute must be raised first with the weight of the attribute in question. This process is the same as the normalization process [6].

III. Methods

SAW Method

The steps of the SAW method [3]:

a. Determine the criteria that will be used as a reference in making decisions, namely Ci.
b. Determine the suitability rating of each alternative on each criterion.
c. Make a decision matrix based on criteria (Ci), then normalize the matrix based on the equation that is adjusted to the type of attribute (attribute benefit or cost attribute) so that the normalized R matrix is obtained.

Normalization of Matrix (R), by formula:

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{max_i\, x_{ij}} & If\ j\ is\ an\ attribute\ of\ the\ advantages\ (benefits) \\ \dfrac{min_i x_{ij}}{x_{ij}} & if\ j\ is\ the\ cost\ attribute\ (cost) \end{cases}$$

Information:

r_{ij} = Normalized branch value
x_i = The attribute value of each criterion
$Max_i\ x_{ij}$ = The biggest value of each criterion
$Min_i\ x_{ij}$ = The smallest value of each criterion
Benefit = The greatest amount of value is best
Cost = The smallest amount is the best

Where r_{ij} is the normalized performance rating of the alternative A_i in the attributes C_j, i = 1,2, ..., m and j = 1,2, ..., n

The final results obtained from the ranking process is the sum of the normalized matrix R multiplication with a weight vector preferences to obtain the greatest value is selected as the best alternative for instance (A_i).

Ranking (V), with the formula:

$$V_i = \sum_{j=1}^{n} w_j r_{ij}$$

Information:

V_i = Ranking for each alternative (preference value)
w_j = Weight values for each criterion
r_{ij} = Normalized performance rating value
A larger V_i value indicates that the alternative A_i is selected.

WP Method

The steps of the WP method [6]:

a. Normalization or improvement of weight W

$$w_j = \frac{w}{\sum w} \text{ Where } \sum w_j = 1$$

b. Determine the value of the vector S

$$S_i = \prod_{j=1}^{n} {x_{ij}}^{w_j} \; Where \; i = 1,2,\dots,m$$

Where Wj is the rank positive for the benefit attribute, and is negative for the cost attribute.

Information:
Π : Product / Number of times
S_i : Score / value of each alternative...
X_{ij} : Alternative value i towards j attribute
W_j : Weights of each attribute or criteria
n : Many criteria

c. Determine the value of vector V
The relative preference of each alternative to find the best alternative is given as follows:

$$V_i = \frac{S_i}{\prod_{j=1}^{n} (x_j{}^*)^{w_j}}$$

Information:

V : Alternative preferences analogized as a vector V
X : Criteria Value
W : Weight of criteria / sub-criteria
i : Alternative
j : Criteria
n : Many Criteria
S : Alternative preferences analogized as a vector S
* : The number of criteria that have been rated on the vector S

$\prod_{j=1}^{n}(x_j^*)^{w_j}$: The sum of the results of multiplying alternative ratings per attribute

The biggest V_i value states that the alternative A_i is selected.

IV. RESULTS

Alternative and Criteria Data

Alternatives in the decision support system for selecting outstanding students using 105 students in the 7th grade of the 2017/2018 school year who are candidates in the process of selecting outstanding students. With the criteria proposed as a reference for the selection of outstanding students:

Table 1. Criteria

Code	Criteria (C_i)	Weight Values (W_i)	Category / Attribute
C1	Average Value of Semester 1	5	Benefit
C2	Average Value of Semester 2	5	Benefit
C3	Attitude Value	4	Benefit
C4	Absence	4	Cost
C5	Activeness of extracurricular activities	3	Benefit

Where weight normalization is done so that the weight values for each criterion are normal, using the formula:

$$w_j = \frac{w}{\sum w} \text{ Where } \sum w_j = 1$$

From the results obtained, the normalization of the weights of each criterion is as follows:

Table 2. Normalization Weight

Code	Criteria (C_i)	Normalization Weight
C1	Average Value of Semester 1	0.238095238
C2	Average Value of Semester 2	0.238095238
C3	Attitude Value	0.19047619
C4	Absence	0.19047619
C5	Activeness of extracurricular activities	0.142857143
Total (Σw_j)		1

Where the giving of variable values is used as an indicator of evaluating all criteria in the selecting outstanding students, as follows:

Table 3. Criteria Value

No	Criteria	Value
1.	Average Value of Semester 1	Taken from the average value of the knowledge and skills of all odd semester subjects.

2.	Average Value of Semester 2	Taken from the average value of the knowledge and skills of all even semester subjects.
3.	Attitude Value	Taken from the average value of attitude 1 and attitude 2 all subjects in the semester odd and even.
4.	Absence	Taken from the number of absences of students (illness, permission, and without information) in learning activities in the even semester. Where with the rating attribute: • = 0 5 • 1 4 • 2 3 • 3 2 • >3 1
5.	Activeness of extracurricular activities	Taken from the large number of extracurricular activities attended by students in the even semester.

Assessment Matrix Data

Following is the assessment matrix on each alternative of each criterion which can be seen in table 4:

Table 4. Assessment Matrix Data

Alternative Code	Criteria				
	C1	C2	C3	C4	C5
A1	76.0771	76.075	3.2	1	1
A2	73.5146	72.6167	3.3	1	2
A3	78.425	79.7875	3.15	1	1
A4	74.9458	74.3208	2.9	5	2
A5	80.2292	81.4167	3	5	2
…… and so on until the alternative code to A105					

SAW Calculation Method

The steps for execution SAW method are:

a. Normalize matrices based on equations that are adjusted to the type of attribute (attribute benefit or cost attribute) so that the normalized R matrix is obtained. Normalization of Matrix (R), by the formula:

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{max_i\, x_{ij}} & If\ j\ is\ an\ attribute\ of\ the\ advantages\ (benefits) \\ \dfrac{min_i x_{ij}}{x_{ij}} & if\ j\ is\ the\ cost\ attribute\ (cost) \end{cases}$$

Here's one of the matrix normalization processes (R) based on C1 from alternative 1 (A1):

$$r_{11} = \frac{C1\ value\ of\ alternative\ 1}{max\ \ value\ of\ the\ value\ C1} = \frac{76.07708}{88.51458} = 0.859486426$$

After all values are normalized, the results can be seen in table 5, below:

Table 5. Normalization Result

Alternative Code	Criteria				
	C1 (+)	C2 (+)	C3 (+)	C4 (-)	C5 (+)
Max/Min	88.51458	89.7667	3.65	1	5
A1	0.859486426	0.84747462	0.876712329	1	0.2
A2	0.830536393	0.808949198	0.904109589	1	0.4
A3	0.886012225	0.888831827	0.863013699	1	0.2
A4	0.846706045	0.827932853	0.794520548	0.2	0.4
A5	0.906394969	0.906981097	0.821917808	0.2	0.4
…… and so on until an alternative code to the A105 based on the process of calculating Normalized Matrix (R).					

b. Then do the ranking process by doing the sum of the normalized matrix R multiplication with weight vector preferences so that the greatest value is chosen as the best alternative for instance (A_i). Phase Ranking (V), by formula:

$$V_i = \sum_{j=1}^{n} w_j r_{ij}$$

The greater preference value (V) indicates that the alternative is the best alternative. Following is one of the ranking processes (V) of alternative 105 (A105):

V105 = (0.92724837*0.238095238)+(0.941723378 *0.238095238)+(0.869863014*0.1904761 9)+(1*0.19047619)+(1* 0.142857143)

= 0.94401479979849

Table 6. Ranking Results

Alternative name	Preference (V)	RANK
Alternatif 105	0.94401479979849	1
Alternatif 92	0.93214244442452	2
Alternatif 29	0.92341476814933	3
Alternatif 28	0.91483356542965	4
Alternatif 96	0.89937772582845	5
Alternatif 74	0.89488156889695	6
Alternatif 21	0.89289352424833	7
Alternatif 77	0.88343612956400	8
Alternatif 14	0.88258317025440	9
Alternatif 37	0.86987679736327	10

WP Calculation Method

The steps for execution WP method are:

Determine the value of the vector S, by formula:

$$S_i = \prod_{j=1}^{n} x_{ij}^{w_j} \; where \; i = 1,2,\dots,m$$

Where W_j is the rank positive for the benefit attribute, and is negative for the cost attribute. The following is one of the processes of calculating the value of the vector S:

S_1 = $(76.07708^{0.238095238})*(76.075^{0.238095238})*(3.2^{0.19047619})*(1^{(-0.19047619)})*(1^{0.142857143})$

= 9.8186408811

After all alternative data have been calculated based on the process of calculating vector S, then all S vector values are added. The following is a table of the value of the vector S that has been calculated:

Table 7. Value of Vector S

Alternative Code	Criteria					S
	C1 (+)	C2 (+)	C3 (+)	C4 (-)	C5 (+)	
A1	76.07708	76.075	3.2	1	1	9.8186408811
A2	73.51458	72.6167	3.3	1	2	10.6966408440
A3	78.425	79.7875	3.15	1	1	9.9728326283
A4	74.94583	74.3208	2.9	5	2	7.7591449856
A5	80.22917	81.4167	3	5	2	8.1113215343
…… and so on until an alternative code to the A105 based on the process of calculating vector S.						
Total S						995.7044937005

Determine the value of vector V, by formula:

$$V_i = \frac{S_i}{\prod_{j=1}^{n} (x_j^*)^{w_j}}$$

After calculating the value of vector S and has added up all the value of vector S, then looking for the value of the vector V. The following is one of the processes of calculating the value of the vector V:

$$V_{105} = \frac{12.8826826050}{995.7044937005} = 0.012938258977985$$

After all the value of the vector V are obtained, then do the ranking process by looking for the largest value of the vector V and the largest value of the vector V states that the alternative chosen as the best alternative.

Table 8. Value of Vector V and Ranking Results

Alternative name	Preference (V)	RANK
Alternatif 105	0.012938258977985	1
Alternatif 92	0.012774249888068	2
Alternatif 29	0.012648333074201	3
Alternatif 28	0.012526324976835	4

Alternatif 96	0.012302814904235	5
Alternatif 74	0.012252291421934	6
Alternatif 21	0.012214406688412	7
Alternatif 77	0.011986540664419	8
Alternatif 37	0.011800181934289	9
Alternatif 14	0.011744878969794	10

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V. DISCUSSION

From the results of the implementation of the system that has been done, where this decision support system uses the SAW and WP methods that produce a ranking sequence in the selection of outstanding students. The following are the top 10 rankings from the results of the calculation of the SAW and WP methods in the selection of outstanding students.

Table 9. The Top 10 Ranking of the Results of Each Method

No.	Student's name	The final result	Ranked SAW	The final result	Ranked SAW
1.	Alternative 105	0.94401479979849	1	0.012938258977985	1
2.	Alternative 92	0.93214244442452	2	0.012774249888068	2
3.	Alternative 29	0.92341476814933	3	0.012648333074201	3
4.	Alternative 28	0.91483356542965	4	0.012526324976835	4
5.	Alternative 96	0.89937772582845	5	0.012302814904235	5
6.	Alternative 74	0.89488156889695	6	0.012252291421934	6
7.	Alternative 21	0.89289352424833	7	0.012214406688412	7
8.	Alternative 77	0.88343612956400	8	0.011986540664419	8
9.	Alternative 14	0.88258317025440	9	0.011744878969794	10
10.	Alternative 37	0.86987679736327	10	0.011800181934289	9

The difference in the ranking order of each method is because the final value calculation process is done differently, in which the SAW method is normalized first of the values of each alternative on each criterion. Furthermore, the results of normalization of each value multiplied by the value of the weight of improvement of each criterion then summed.

Whereas in the WP method, a vector S is calculated by multiplying the value of each alternative raised by the value of the weight of improvement for each criterion. Then the value of vector S of each alternative will be the division with a total value of vector S of the overall alternative to get the value of the vector V (final value).

Based on the calculation process, it is known that the results obtained from the WP method are more accurate than the results obtained from the SAW method because the WP method uses multiplication and appointment in the calculation process. As in the journal [7] which states that ranking using WP is more accurate than SAW because of the best alternative calculation is obtained from multiplying the performance rating value then raised with the value of the weight that has been fixed. Similarly in [8] which states that the results of the calculation of the WP method are known to be more accurate than the results of the calculation of the SAW method, because the WP method utilizes multiplication of the performance rating values raised with the fixed weight value.

Based on the execution time in the calculation of each method in the support system for the selection of outstanding students with 105 data processed, it is known that the SAW method requires an execution time of around 4,390659 seconds. While the WP method requires execution time of around 8.694217 seconds. This is because the calculation process in the SAW method is simpler than the WP method because the SAW method calculation process uses

summation from the results of the multiplication of normalization values by improving the weight of the criteria, while the WP method calculates the S value of each alternative with a total value of the whole vector value S, where the value of vector S is obtained by multiplying each alternative value that has been raised with the value of the improvement of the weight of each criterion.

So in terms of the execution time required by each method in calculating the support system for the selection of high achieving students, it can be concluded that the SAW method is slightly faster than the WP method because of the simplicity in the calculation process in the SAW method compared to the WP method. Where in the study conducted by Velasquez and Hester (2013) in the journal [8] stated that with the simplicity of the calculation, the SAW method was the fastest in performing the calculation process compared to the calculation process from other MCDM methods.

Based on the Relative Standard Deviation (RSD) test to determine the accuracy of each method, where the calculation of the RSD value is done on the calculation of the SAW and WP methods taken from the calculation of the value of Vi in each of the two methods using the formula, as follows [9]:

$$RSD = \frac{SD}{\bar{x}} \times 100\%$$

Information:

RSD : The relative standard deviation value stated in (%)
SD : Standard deviation of alternative preferences (V_i)
$\bar{X}$: The average value of alternative preferences (V_i)

After searching the value of SD and $\bar{x}$, are known to:

a. For the SAW method, the RSD results are obtained $\frac{0.078603861735857}{0.751523296497046} \times 100\% = 10.46\%$.

b. For the WP method, the RSD results are obtained $\frac{0.00140402721091786}{0.00952380952380953} \times 100\% = 14.74\%$.

Based on the calculations obtained, the RSD value in the SAW method is 10.46% while the RSD value on the WP method is 14.74%. Where it can be said that the RSD value in the WP method is higher than the RSD value in the SAW method. So it can be concluded that the value generated from the calculation of the WP method is better than the value generated from the calculation of the SAW method. As in the journal [10] which states that the higher the value of RSD, the calculation with the resulting method is more optimal.

VI. CONCLUSIONS

With the construction of a decision support system for the selection of outstanding students to assist and facilitate the schools in selecting and determining outstanding students. The system built using the SAW method and the WP method can provide ranking results that can be used as recommendations in the selection of outstanding students.

From the results of the implementation of the system using the two methods, it was found that the results of the ranking order of each method had almost the same rank order, but there were some different ones as in the results of the ranking of ninth and tenth ranks. The ranking difference is because the calculation process of each method is done differently. Where based on the calculation process, it is known that the results obtained from the WP method are more rigorous compared to the results obtained from the SAW method because the WP method uses multiplication and appointment in the calculation.

Based on the execution time in the calculation of each method on the selection decision support system of high achieving students, it shows that the SAW method is slightly faster than the WP method. This is because the calculation process of each method is different, where the SAW method in the calculation process is simpler than the WP method.

Based on the testing of Relative Standard Deviation (RSD) to determine the level of accuracy of each method, the RSD value obtained in the SAW method is 10.46% while the RSD value on the WP method is 14.74%. So it can be concluded that the value generated from the calculation of the WP method is better than the value generated from the calculation of the SAW method.

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