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Comparison of Decision Support Systems in Selecting Extracurricular Activities Using SAW, WP, and TOPSIS Methods

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A B S T R A C T

The selection of extracurricular activities that align with students' interface and potential is basic for character and ability improvement in schools. This study aims to compare the effectiveness of three decision support system (DSS) methods: Simple Additive Weighting (SAW), Weighted Product (WP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The factors utilized incorporate physical condition, time availability, potential, interest, talent, and previous achievements. Data were collected through student questionnaires and processed using the three DSS methods. The results show differences in ranking outcomes and reveal the strengths and weaknesses of each method. This study contributes to the development of multi-criteria DSS in educational decision-making.

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INTRODUCTION

Extracurricular activities are an important part of the education world that not only function as a complement to learning but also play a role in shaping character, developing interests, and enhancing student potential. In practice, the selection of extracurricular activities in many schools is still done subjectively, without a systematic and data-based approach. This results in a mismatch between the activities chosen by students and the potential and interests they actually have.

One of the solutions that can be applied to address this issue is the use of a Decision Support System (DSS) based on multi-criteria decision-making methods. The DSS is a system that can assist in the assessment and decision-making process by considering various criteria in a structured manner(Azfandi, n.d.). Some commonly used methods in Decision Support Systems (DSS) are Simple Additive Weighting (SAW), Weighted Product (WP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Nugroho et al., n.d.; Yunia Pasa et al., 2023). The three methods have proven effective in assisting the selection process in various fields such as laptop selection (Azfandi, n.d.), selection of exemplary employees (Elektronika & Komputer, 2023), until scholarship selection (Taufiq Subagio & Thoip Abdullah, n.d.).

Several previous studies have also compared the SAW and WP methods in the context of selecting extracurricular activities, but not many have compared all three comprehensively in a single case study (Cahyati et al., n.d.). Therefore, this research contributes to the enrichment of knowledge by presenting a comparison of the three decision support methods in the context of selecting extracurricular activities for students. This study also utilizes a unique sample of junior high school students with assessment criteria that include interest, potential, physical condition, availability of time, and extracurricular achievements.

Thus, the objective of this research is to develop and compare decision support systems in the selection of student extracurricular activities using the SAW, WP, and TOPSIS methods, as well as to evaluate which method is most suitable for producing accurate recommendations based on multi-criteria preferences.

THEORETICAL REVIEW

Simple Additive Weighting (SAW) Method

The Simple Additive Weighting (SAW) method is one of the most widely used and simplest multi-criteria decision-making techniques. This method works by summing up the weighted normalized scores of each alternative based on each criterion. The values are first normalized and then multiplied by the respective weights (Taufiq Subagio & Thoip Abdullah, n.d.). The steps of calculation using the SAW method are (Penta et al., 2019; Sari et al., 2021; Yunia Pasa et al., 2023):

1. Ensuring alternatives
2. Ensuring the reference criteria (C_i), as well as ensuring criteria with cost value and criteria with benefit value
3. Converting the existing alternative values to the suitability rating values for each criterion

4. Calculating the importance weight level (W), where W = [W_1, W_2, W_3, … W_j]
5. Creating a decision matrix X derived from the suitability rating table for each criterion for each criterion
6. Normalizing the decision matrix X using the formula:

$$r_{ij} = \begin{cases} \frac{X_{ij}}{max\,(X_{ij})}, if\ benefit \\ \frac{min\,(X_{ij})}{X_{ij}}, if\ cost \end{cases} \quad \text{…………… (1)}$$

Description:
r_{ij} : normalized criteria rating value
X_{ij} : attribute value of each criterion
$max(X_{ij})$: maximum value of criterion W for each alternative
$min(X_{ij})$: minimum value of criterion W for each alternative

7. Create a normalized matrix (R) based on the results of the normalized performance ratings, using the formula:

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots\ r_{1j} \\ r_{i1} & r_{i2} & \dots\ r_{ij} \end{bmatrix} \quad \text{…………… (2)}$$

Description:
R : normalized matrix
r_{ij} : normalized criteria rating value

8. Calculating the final result (V), by adding the product of the normalized matrix R and the weight of importance W, using the formula:

$$V_i = \sum_{j=1}^{n} W_j \quad r_{ij} \quad \text{…………… (3)}$$

Description:
V_i : ranking of each alternative
W_i : weight of each criterion
r_{ij} : normalized criteria rating value

9. Sorting the results (Vi) from highest to lowest.

Weighted Product (WP) Method

The Weighted Product (WP) method differs from SAW in that it uses multiplication rather than addition. Each criterion value is raised to the power of its assigned weight and then multiplied together to produce the final score of each alternative (Humairoh et al., 2022). The steps from the determination of Weighted Product are (Diana & Seprina, 2019; Fransiska, 2023; Laila & RMS, 2019; Murtina, 2022; Yunia Pasa et al., 2023):

1. Ensuring alternatives
2. Ensuring the reference criteria (C_i), as well as ensuring criteria with cost value and criteria with benefit value
3. Ensuring the weight of each criterion (W), then normalizing that weight using the formula:

$$W_j = \frac{W_j}{\sum W_j} \quad \text{…………… (4)}$$

Description:
W_j : weight of each criterion

The result of weight normalization must meet the requirement that the sum of the normalized weights for all criteria is 1.

4. Calculating the vector value (S) for each alternative, by raising the attribute values of the alternatives at each criterion to the power of the weights from the same criterion, then multiplying all of them, using the formula:

   $$S_i = \prod_{j=1}^{n} X_{ij}^{W_j} \qquad \text{..............} (5)$$

   Description:
   S_i : vector value on a certain alternative
   X_{ij} : criteria value
   W_j : weight of each criterion, where if the criterion is benefit, then the weight has a positive value, whereas if the criterion is cost, then the weight has a negative value
5. Calculating the vector value (V) for each alternative (preference of alternatives), by dividing the S vector value of each alternative by the total S vector value, using the formula:

   $$V_i = \frac{S_i}{\prod_{j=1}^{n} (X_j)^{W_j}} \qquad \text{..............} (6)$$

   Description:
   V_i : alternative preference
   X : criterion value
   W_j : weight of each criterion
6. Sorting the vector values (V) of all alternatives, from the highest to the lowest values.

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

TOPSIS is an MCDM method that selects the best alternative based on its closeness to the positive ideal solution and its distance from the negative ideal solution. The closer an alternative is to the ideal solution and the farther it is from the worst-case scenario, the better its rank (Widiyawati et al., 2022; Yunia Pasa et al., 2023). The steps for determination using the TOPSIS method are as follows (Nugroho et al., n.d.; Widiyawati et al., 2022):

1. Ensuring alternatives
2. Determine the criteria and weights
3. Create a normalized decision matrix (R), using the formula:

   $$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^{n} X_{ij}^2}} \qquad \text{..............} (7)$$

   Description:
   r_{ij} : the element of the normalized decision matrix R
   X_{ij} : the element of the decision matrix X
4. Determining the weighted normalized decision matrix, using the formula:

   $$y_{ij} = W_i \ r_{ij} \qquad \text{..............} (8)$$

   Description:
   y_{ij}: element of the weighted normalized decision
   W_i: weight of each criterion
   r_{ij} : element of the normalized decision matrix R

5. Determining the positive ideal solution matrix and the negative ideal solution, by examining the weighted normalized matrix values, among others:
   $A^+ = (y_1^+, y_2^+, y_3^+, \dots, y_n^+)$ …………… (9)
   and
   $A^- = (y_1^-, y_2^-, y_3^-, \dots, y_n^-)$ …………… (10)
   Description:
   A^+: positive ideal solution matrix
   A^-: negative ideal solution matrix

   Where:
   $$y_j^+ = \begin{cases} max(y_{ij}), if\ j = attribution\ of\ benefit \\ min(y_{ij}), if\ j = attribution\ of\ cost \end{cases}$$
   and
   $$y_j^- = \begin{cases} min(y_{ij}), if\ j = attribution\ of\ benefit \\ max(y_{ij}), if\ j = attribution\ of\ cost \end{cases}$$

6. Calculating the distance between the value of each alternative with the positive ideal solution matrix and the negative ideal solution matrix, using the formula:
   $D_i^+ = \sqrt{\sum_{j=1}^{n}(y_i^+ - y_{ij})^2}$ …………… (11)
   and
   $D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)^2}$ …………… (12)
   Description:
   D^+ : value of the distance of alternatives with the positive ideal solution matrix
   D^- : value of the distance of alternatives with the negative ideal solution matrix

7. Determining the preference value for each alternative (V), using the formula:
   $V_i = \frac{D_i^-}{D_i^- + D_i^+}$ …………… (13)
   Description:
   V_i : the preference value of each alternative
8. Sorting the preference values of all alternatives, from the highest to the lowest.

Sensitivity Test

Sensitivity testing is a test to determine the level of sensitivity of a method to a case. This testing is conducted in order to compare several methods, so that the sensitivity levels for those methods can be determined. If there is one change in the ranking of methods that makes it more sensitive, then that method will be chosen over the others. (Fauzi et al., 2020; Yunia Pasa et al., 2023).

The steps for implementing sensitivity testing are as follows (Fauzi et al., 2020; Jayawardani & Maryam, 2022; Yunia Pasa et al., 2023):

1. Determine all attribute weights, where W_j = 1, with j = 1,2,3,..., n (number of attributes)
2. Change the weight of a certain attribute by a distance of 1-2, while the other weights remain the same
3. Normalize the criteria weights so that they sum to 1
4. Apply the results of the normalization of the criteria weights from step 3 to the compared methods
5. Calculate the percentage change in rankings that occurs in these methods, by comparing it to the initial condition when the weights have not been changed/are the same.

This research uses the method illustrated in the following figure 1.

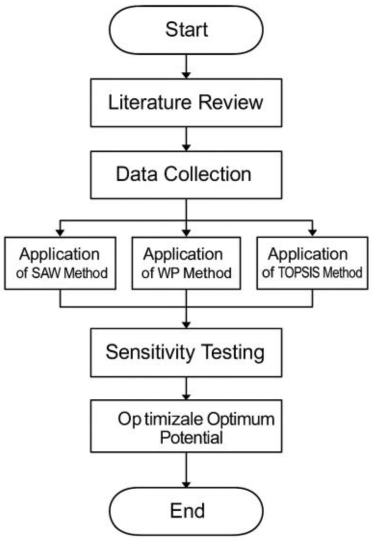

Figure 1. Research method

METHODOLOGY

Data Collection Techniques

In this research, data were collected using four main techniques to ensure the completeness and accuracy of the information needed for decision-making analysis:

1. Observation
   Direct observation was conducted to understand the extracurricular activities available at the school, their schedules, and facilities. This helped provide context to the criteria used in the decision-making process.
2. Interviews
   Semi-structured interviews were conducted with school staff and extracurricular activity coordinators to gather insights regarding the importance of each criterion (e.g., physical ability, interest, and achievement) and to validate the criteria used in the model.

3. Questionnaires
   Closed-ended questionnaires were distributed to students to obtain assessments of each extracurricular activity based on the defined criteria. The results of these questionnaires formed the main data for analysis using SAW, WP, and TOPSIS methods.
4. Literature Study
   A literature review was conducted to support the selection of criteria and decision-making methods. Sources included academic journals, books, and previous research related to multi-criteria decision making and student extracurricular selection.

RESULTS AND DISCUSSION

Description of The Results Obtained

Table 1. Alternative

No	Alternative
1.	Pramuka
2.	PMR
3.	Paskibra
4.	Pencak Silat

When choosing a good extracurricular activity, there are several criteria along with their weights, where the total weighting must add up to 10. Here are the criteria along with their weights:

Table 2. Weights and Criteria

ID Criteria	Criteria Name	Weight
C1	Physical	3
C2	Time availability	2
C3	Potential	1
C4	Interest	2
C5	Talent	1
C6	Previous achievements	1
Total		10

The following table shows the weights and types of each criterion used in this research.

Table 3. Criteria and Wight of Assessment

ID Criteria	Criteria Name	Type of Criteria	Weight
C1	Physical	Benefit	3
C2	Time availability	Cost	2
C3	Potential	Benefit	1
C4	Interest	Benefit	2
C5	Talent	Benefit	1
C6	Previous achievements	Benefit	1

The next process is to determine the range of values for each of the existing criteria, here is the range of values for those criteria:

Table 4. Score Range on Each Criterion

Criteria Name	Score Range	
	Range	Score
Physical	Height > 165	5
	Height > 155	4
	Height > 145	3
	Height > 135	2
	Height > 125	1
Time availability	Very Good	1
	Good	2
	Enough	3
	Lack	4
	Very Lacking	5
Potential	Very Good	5
	Good	4
	Enough	3
	Lack	2
	Very Lacking	1
Interest	Very Interest	5
	Interest	4
	Sufficient Interest	3
	Less Interest	2
	Very Less Interest	1
Talent	Very Talent	5
	Talent	4
	Quite Talented	3
	Less Talented	2
	Very Less Talented	1
Previous achievements	Very Good	5
	Good	4
	Enough	3
	Lack	2
	Very Lacking	1

The table below shows the rating results of the alternatives against each criterion, and this suitability data will be used for calculations in the SAW, WP, and TOPSIS methods.

Table 5. Alternative Data and Criteria on Students

No	Extracurricular Name	Range					
		C1	C2	C3	C4	C5	C6
1	Pramuka	H : 140	Lack	Very Good	Very Interest	Talent	Very Good
2	PMR	H : 140	Lack	Enough	Interest	Less Talented	Good
3	Paskibra	H : 140	Lack	Very Good	Sufficient Interest	Very Talent	Good

4	Pencak Silat	H : 140	Lack	Very Lacking	Very Less Interest	Very Less Talented	Good

Table 6. Alternative Suitability Rating Against Criteria on Students

No	Extracurricular Name	Range					
		C1	C2	C3	C4	C5	C6
1	Pramuka	2	4	4	5	4	5
2	PMR	2	4	3	4	3	4
3	Paskibra	2	4	5	3	5	4
4	Pencak Silat	2	4	1	1	1	4

1. SAW Calculation

Normalization

$R11 = \frac{2}{max\,\{2,2,2,2\}} = \frac{2}{2} = 1$ $\quad R31 = \frac{2}{max\,\{2,2,2,2\}} = \frac{2}{2} = 1$

$R21 = \frac{2}{max\,\{2,2,2,2\}} = \frac{2}{2} = 1$ $\quad R41 = \frac{2}{max\,\{2,2,2,2\}} = \frac{2}{2} = 1$

The results of normalization 1 to normalization 6 are as follows:

$$\begin{bmatrix} 1 & 1 & 0.8 & 1 & 0.8 & 1 \\ 1 & 1 & 0.6 & 0.8 & 0.6 & 0.8 \\ 1 & 1 & 1 & 0.6 & 1 & 0.8 \\ 1 & 1 & 0.2 & 0.2 & 0.2 & 0.8 \end{bmatrix}$$

Determining the preference value for each alternative Here are the calculations:

$V1 = (4)(1) + (4)(1) + (3)(0.8) + (3)(1) + (3)(0.8) + (3)(1) = 18.8$

$V2 = (4)(1) + (4)(1) + (3)(0.6) + (3)(0.8) + (3)(0.6) + (3)(0,8) = 16.4$

$V3 = (4)(1) + (4)(1) + (3)(1) + (3)(0.6) + (3)(1) + (3)(0.8) = 18.2$

$V4 = (4)(1) + (4)(1) + (3)(0.2) + (3)(0.2) + (3)(0.2) + (3)(0.8) = 12.2$

The results of the SAW method show that the highest preference value is 18,8 for the first alternative. The order of alternatives based on preference value from high to low is A1, A3, A2, A4.

2. WP Calculation

Normalization $\frac{W_j}{\sum W_j} = \frac{3}{10} = 0.3$

The result of normalization is 0.3, 0.2, 0.1, 0.2, 0.1, 0.1 . Next, calculations are performed on the value of S for each alternative. In determining the value of S, if the criterion is profit, positive exponentiation is used, while for cost criteria, negative exponentiation will be used. The following are the calculations:

$S1 = (2^{0.3}) \times (4^{-0.2}) \times (4^{0.1}) \times (5^{0.2}) \times (4^{0.1}) \times (5^{0.1}) = 1.995$

$S2 = (2^{0.3}) \times (4^{-0.2}) \times (3^{0.1}) \times (4^{0.2}) \times (3^{0.1}) \times (4^{0.1}) = 1.762$

$S3 = (2^{0.3}) \times (4^{-0.2}) \times (5^{0.1}) \times (3^{0.2}) \times (5^{0.1}) \times (4^{0.1}) = 1.842$

$S4 = (2^{0.3}) \times (4^{-0.2}) \times (1^{0.1}) \times (1^{0.2}) \times (1^{0.1}) \times (4^{0.1}) = 1.072$

The sum of values S1-S4 is 6.671. The next step is to determine the preference value vector V for each alternative with the total value S of all alternatives. Here are the calculations:

$V1 = \frac{1.995}{6.671} = 0.299 \qquad V3 = \frac{1.842}{6.671} = 0.276$

$V2 = \frac{1.762}{6.671} = 0.264 \qquad V4 = \frac{1.072}{6.671} = 0.161$

The results of the WP method show the highest preference value for student 1, which is 0.299 for the first alternative. The order of alternatives from highest to lowest preference value is A1, A3, A2, A4.

3. TOPSIS Calculation

Normalization Matrix $r_{11} = \frac{2}{\sqrt{(2^2)+(2^2)+(2^2)+(2^2)}} = 0.5$

Table 7 Normalized Decision Matrix

Extracurricular Name	Range					
	C1	C2	C3	C4	C5	C6
Pramuka	0.5	0.5	0.57	0.63	0.57	0.59
PMR	0.5	0.5	0.43	0.5	0.43	0.47
Paskibra	0.5	0.5	0.71	0.38	0.71	0.47
Pencak Silat	0.5	0.5	0.14	0.13	0.14	0.47

Weighted Normalization Matrix $y_{11} = W_1 \times r_{11} = 3 \times 0.5 = 1.5$

Table 8. Weighted Normalization Matrix

Extracurricular Name	Range					
	C1	C2	C3	C4	C5	C6
Pramuka	1.5	1	0.57	1.26	0.57	0.59
PMR	1.5	1	0.43	1	0.43	0.47
Paskibra	1.5	1	0.71	0.76	0.71	0.47
Pencak Silat	1.5	1	0.14	0.26	0.14	0.47

Counting positive and negative ideal solutions

Table 9. Ideal Solutions Positive and Negative

Criteria	A+	A-
C1	0.083	0.083
C2	0.083	0.083
C3	0.117	0.023
C4	0.117	0.023
C5	0.117	0.023
C6	0.098	0.078

Distance to positive and negative ideal solutions

Table 10. Distance to positive and negative ideal solutions

Alternative	D+	D-
A1	0.198	1.177
A2	0.489	0.846
A3	0.514	0.949
A4	1.290	0.023

The next step is to calculate the preference value of each alternative using the formula:

$$V_i = \frac{D_i^-}{D_i^- + D_i^+}$$

Table 11. Preference Value

Alternative	Preference
A1	0.856
A2	0.634
A3	0.649
A4	0.000

4. Sensitivity Test

Table 12. Results of SAW, WP, TOPSIS Methods

Alternative	SAW Method	WP Method	TOPSIS Method
A1	18.8	0.299	0.856
A2	16.4	0.264	0.634
A3	18.2	0.276	0.649
A4	12.2	0.161	0.000
Maximal	18.8	0.299	0.856

After all the preference values of the alternatives in each method (SAW, WP, and TOPSIS) were calculated and ranked, the next step is to test the sensitivity of each method to determine how sensitive the ranking of alternative preference values would be if the weights were modified.

In this study, the sensitivity test scenario was conducted by modifying the weight of one criterion at a time—by adding 0.5 and 1—while the weights of the other criteria remained unchanged. This process was performed iteratively until each criterion underwent both modification scenarios.

The following table shows the results of the sensitivity test on the three methods:

Table 13. Results of Sensitivity Testing of SAW, WP, and TOPSIS

Criteria Modified	SAW	WP	TOPSIS
C1 + 0.5	0.898	0.296	0.860
C1 + 1	0.933	0.299	0.863
C2 + 0.5	0.881	0.291	0.844
C2 + 1	0.864	0.287	0.837
C3 + 0.5	0.892	0.297	0.857
C3 + 1	0.887	0.296	0.855
C4 + 0.5	0.906	0.301	0.868

C4 + 1	0.914	0.304	0.872
C5 + 0.5	0.898	0.297	0.860
C5 + 1	0.890	0.298	0.861
C6 + 0.5	0.890	0.298	0.861
C6 + 1	0.890	0.298	0.861
Sum (%)	7.68	5.74	4.07

Based on Table 13 above, the sensitivity value of the SAW method is 7.68%. The sensitivity value of the WP method is 5.74%, and the sensitivity value of the TOPSIS method is 4.07%.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the study, it can be concluded that all three decision-making methods SAW, WP, and TOPSIS produced consistent rankings, with the first alternative (Pramuka) consistently achieving the highest preference score. The application of these methods has proven effective in supporting the selection of extracurricular activities based on multiple weighted criteria, including physical ability, time availability, potential, interest, talent, and previous achievements.

The sensitivity test also indicated that the TOPSIS method showed relatively stable results compared to the other two methods when changes in criteria weights were applied. Therefore, the TOPSIS method can be considered the most optimal and reliable approach for this case.

Recommendation:

It is recommended for schools or institutions to adopt multi-criteria decision-making methods like TOPSIS when assisting students in selecting extracurricular activities, especially when multiple evaluation criteria are involved. A digital decision support system could also be developed to automate and simplify the selection process.

ADVANCE RESEARCH

This study is limited by the number of criteria and alternatives evaluated, as well as the fixed scoring system based on qualitative inputs. Future research can explore:

1. The use of fuzzy logic or interval values to handle subjective judgments more accurately
2. Expanding the number of extracurricular alternatives and student samples to improve generalizability
3. Integration with real-time student performance data for dynamic decision support
4. Comparison with other MCDM methods such as AHP, VIKOR, or ELECTRE for broader benchmarking.

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