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Decision Support System for Scholarship Recipients at Bhakti Setya Indonesia Health Polytechnic Foundation Using SAW and TOPSIS Methods

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Abstract

The scholarship selection system at the Bhakti Setya Indonesia Health Polytechnic Foundation is still conducted manually, making it less transparent and time-consuming. This process requires an objective and measurable method to ensure fairness in determining scholarship recipients. This study aims to develop a decision support system for scholarship selection using Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. The SAW method calculates scores based on aggregating weighted normalized values, while the TOPSIS method evaluates candidates based on their proximity to ideal solutions. The criteria used in this study include parental income, number of dependents, GPA, organizational involvement, and achievements. The results indicate that the developed system can rank candidates with high accuracy. Candidates with the best performance consistently ranked at the top in the results of both methods.

Keywords: Decision support system; Scholarship selection; SAW method; TOPSIS method; Multi-criteria evaluation.

Abstrak

Sistem seleksi penerima beasiswa di Yayasan Politeknik Kesehatan Bhakti Setya Indonesia masih dilakukan secara manual, sehingga cenderung kurang transparan dan membutuhkan waktu yang lama. Proses ini membutuhkan metode yang objektif dan terukur untuk memastikan keadilan dalam menentukan penerima beasiswa. Penelitian ini bertujuan untuk membangun sistem pendukung keputusan dalam penentuan penerima beasiswa dengan menggunakan metode Simple Additive Weighting (SAW) dan Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Metode SAW digunakan untuk menghitung skor berdasarkan agregasi nilai normalisasi berbobot, sedangkan metode TOPSIS diterapkan untuk mengevaluasi kandidat berdasarkan kedekatan dengan solusi ideal. Kriteria yang digunakan dalam penelitian ini meliputi penghasilan orang tua, jumlah tanggungan, IPK, keaktifan organisasi, dan prestasi. Hasil penelitian menunjukkan bahwa sistem yang dibangun mampu memberikan peringkat kandidat dengan tingkat akurasi yang baik. Kandidat dengan performa terbaik secara konsisten berada pada peringkat atas dalam hasil perhitungan kedua metode.

Kata-kata kunci: *Sistem pendukung Keputusan; Seleksi beasiswa; Metode SAW; Metode TOPSIS; Evaluasi multikriteria.*

1. Introduction

Access to quality education is a fundamental challenge in developing human resources in Indonesia. Scholarship programs play a crucial role in assisting students from economically disadvantaged backgrounds to achieve academic and non-academic excellence. However, the selection process for scholarship recipients often faces complexities due to the need to consider multiple criteria, such as academic performance, financial need, and extracurricular activities. Errors or biases in this process may lead to inefficiencies and inequities, making a robust decision support system essential to ensure accuracy, objectivity, and transparency.

The Simple Additive Weighting (SAW) method is a widely adopted multi-criteria decision-making (MCDM) technique due to its simplicity in aggregating weighted criteria scores. For example, Azis et al. demonstrated the application of SAW in decision-making for employee recruitment, emphasizing its efficiency in processing multiple criteria systematically **[1]**. Similarly, the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) method is known for evaluating alternatives relative to an ideal positive and negative solution. Research by Putranto et al. highlighted how TOPSIS effectively enhances decision-making accuracy in ranking alternatives based on their proximity to a perfect solution **[2]**.

Despite the strengths of these individual methods, there is a notable gap in research on integrating SAW and TOPSIS to harness their complementary advantages. SAW excels in simplicity and straightforward computations but may overlook the balance across all criteria, as it heavily favors alternatives with high scores in dominant criteria. Conversely, TOPSIS offers a more holistic evaluation by considering the proximity of other options to both positive and negative ideal solutions. This integration is expected to address the limitations of each method and provide a more reliable framework for complex decision-making scenarios. For instance, Rismayanti et al. implemented a combination of SAW and TOPSIS for selecting recipients of the Kartu Indonesia Pintar scholarship, demonstrating improved decision-making accuracy **[3]**. Additionally, Sadali et al. developed a web-based decision support system using TOPSIS for Bank Indonesia scholarship selection, highlighting the method's effectiveness in handling multiple criteria **[4]**.

This study aims to develop a Decision Support System (DSS) for selecting scholarship recipients at Bhakti Setya Indonesia Health Polytechnic Foundation by integrating the SAW and TOPSIS methods. The proposed system evaluates candidates based on parental income (cost), number of dependents (benefit), grade point average (benefit), organizational involvement (benefit), and non-academic achievements (benefit). By leveraging the strengths of both methods, the DSS seeks to enhance the selection process's accuracy, transparency, and efficiency. The subsequent sections will detail the methodology, system implementation, and evaluation of the proposed approach.

2. Method

This research aims to develop a Decision Support System (DSS) for scholarship selection at Bhakti Setya Indonesia Health Polytechnic Foundation by integrating the Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. These methods were chosen to address the complexities of multi-criteria decision-making, ensuring an accurate, fair, and transparent selection process [1], [2].

The research methodology begins with data collection, including relevant attributes such as parental income, number of dependents, GPA, organizational involvement, and non-academic achievements. Subsequently, the criteria and their respective weights are determined through discussions with the scholarship committee to reflect the foundation's objectives. The SAW method normalizes the data, assigns weights, and calculates scores for each candidate by summing up the weighted normalized values. This process allows the candidates to be ranked based on their aggregated scores [3].

Simultaneously, the TOPSIS method evaluates the candidates by determining the positive ideal solution (best possible performance) and the negative ideal solution (worst possible performance). Each candidate's distance to these ideal solutions is calculated, followed by the computation of preference values to rank the candidates. The integration of SAW and TOPSIS ensures that the DSS leverages the simplicity of SAW and the robustness of TOPSIS for a balanced evaluation [4], [5].

The workflow of the research methodology is summarized in Figure 1, which outlines the step-by-step process from data input to ranking output. The final step involves comparing the rankings produced by SAW and TOPSIS, providing insights into their consistency and reliability in the scholarship selection process [6].

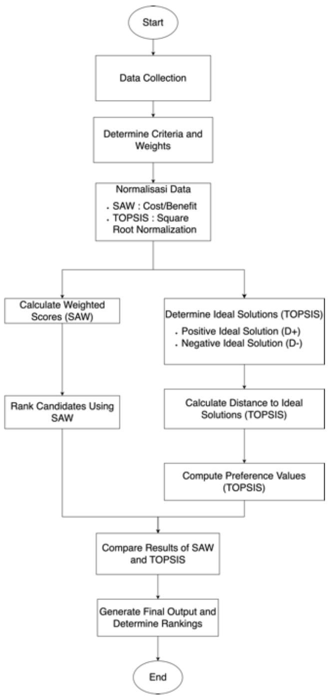

Figure 1. Workflow of the research methodology

2.1 Data Collection

Data were collected from 50 scholarship applicants. The criteria considered in the decision-making process include:

a) Parental Income (C1): Monthly income of the candidate's parents (cost criterion).
b) Number of Dependents (C2): Total family members financially dependent on the candidate's parents (benefit criterion).
c) Grade Point Average (C3): Academic performance represented as GPA (benefit criterion).
d) Organizational Involvement (C4): Participation in student organizations (benefit criterion).
e) Non-Academic Achievements (C5): Awards or accomplishments outside the academic field (benefit criterion).

These criteria were selected based on their relevance to the scholarship objectives, as outlined in previous studies on scholarship selection systems. [1], [2], [3].

2.2 Determination of Criteria Weights

Weights were assigned to each criterion to reflect their importance in the selection process:

a) C1 (Parental Income): 0.25
b) C2 (Number of Dependents): 0.20
c) C3 (GPA): 0.30
d) C4 (Organizational Involvement): 0.15
e) C5 (Non-Academic Achievements): 0.10

These weights were determined through discussions with the scholarship committee and are consistent with methodologies used in similar research [4], [7].

Table 1. Weight of scholarship applicants Recruitment Criteria

Code	Criteria	**Level of importance**	**Criteria Weights**
C1	Parental Income (cost)	5	5/(5+4+6+3+2)=0.25
C2	Number of Dependents (benefit)	4	4/(5+4+6+3+2)=0.20
C3	GPA (benefit)	6	6/(5+4+6+3+2)=0.30
C4	Organizational Involvement (benefit)	3	3/(5+4+6+3+2)=0.15
C5	Non-Academic Achievements (benefit)	2	2/(5+4+6+3+2)=0.10

3. Results and Discussion

The Decision Support System (DSS) for scholarship selection was implemented using the Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. The following are the results obtained from the analysis:

3.1 Implementation of SAW Method

The SAW method calculated normalized scores for each criterion based on benefit or cost attributes. The normalized scores were weighted according to the predetermined importance of each criterion. The final scores for each candidate were computed as the sum of weighted normalized scores. The candidates were then ranked based on these final scores.

The Simple Additive Weighting (SAW) method was applied as follows:

a) Normalization of the Decision Matrix:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\max(x_i)}, if\ j\ is\ a\ benefit\ criterion \\ \frac{\min(x_j)}{x_{ij}}\ \ , if\ j\ is\ a\ cost\ criterion \end{cases} \quad (1)$$

Table 2. Normalization of the Decision Matrix

Alternative	Parental Income	Number of Dependents	GPA	Organizational Involvement	Non-Academic Achievements
Al1	0.20	0.8	1.0	0.2	0.8
Al2	0.250	0.4	1.0	0.8	0.2
Al3	1.0	0.6	0.8	0.2	0.4
Al4	0.5	0.6	0.8	0.8	0.2
Al5	1.0	0.4	1.0	1.0	0.2
Al6	0.25	0.4	1.0	0.6	0.6
Al7	0.25	0.2	0.6	0.6	0.2
Al8	0.20	1.0	0.8	0.2	0.2
Al9	0.50	0.6	0.8	1.0	0.2
Al10	0.20	0.4	0.8	0.2	0.8
…	…	…	…	…	…
Al46	1.0	0.6	0.2	0.8	0.6
Al47	0.50	0.8	0.8	0.4	1.0
Al48	1.0	0.2	0.6	0.8	0.4
Al49	0.50	0.2	1.0	1.0	1.0
Al50	0.33	0.6	1.0	0.6	1.0

b) Calculation of Weighted Scores:

$$V_i = \sum_{j=1}^{n} w_j \cdot r_{ij} \quad (2)$$

Where:

Vi = the total score for candidate i

Wj = is the weight of criterion j

rij = is the normalized value of candidate I for criterion j.

Table 3. Calculation of Weighted Scores

Alternative	Parental Income	Number of Dependents	GPA	Organizational Involvement	Non-Academic Achievements	SAW_Score
Al1	0.05	0.16	0.30	0.03	0.08	0.62
Al2	0.06	0.08	0.30	0.12	0.02	0.58
Al3	0.25	0.12	0.24	0.03	0.04	0.68
Al4	0.12	0.12	0.24	0.12	0.02	0.62
Al5	0.25	0.08	0.30	0.15	0.02	0.80
Al6	0.06	0.08	0.30	0.09	0.06	0.59
Al7	0.06	0.04	0.18	0.09	0.02	0.39
Al8	0.05	0.20	0.24	0.03	0.02	0.54
Al9	0.12	0.12	0.24	0.15	0.02	0.66
Al10	0.05	0.08	0.24	0.03	0.08	0.48
…	…	…	…	…	…	…
Al46	0.25	0.12	0.06	0.12	0.06	0.61
Al47	0.12	0.16	0.24	0.06	0.10	0.68
Al48	0.25	0.04	0.18	0.12	0.04	0.63
Al49	0.12	0.04	0.30	0.15	0.10	0.72
Al50	0.08	0.12	0.30	0.09	0.10	0.69

This method is widely used in decision support systems for scholarship selection and has been proven effective in ranking candidates based on multiple criteria. [8], [9].

3.2 Implementation of TOPSIS Method

The TOPSIS method was implemented as follows:

a) Normalization of the Decision Matrix:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (3)$$

With i=1,2,...m; and j=1,2,...n;

Where:

rij= Element Matrix normalized [i][j]

xij= Element matrix X's decision

Table 4. TOPSIS Normalization of the Decision Matrix

Alternative	Parental Income	Number of Dependents	GPA	Organizational Involvement	Non-Academic Achievements
Al1	00.06	00.18	00.17	00.04	00.17
Al2	00.07	00.09	00.17	00.17	00.04
Al3	00.28	00.14	00.13	00.04	00.09
Al4	00.14	00.14	00.13	00.17	00.04
Al5	00.28	00.09	00.17	00.21	00.04
Al6	00.07	00.09	00.17	00.13	00.13
Al7	00.07	00.05	00.10	00.13	00.04
Al8	00.06	00.23	00.13	00.04	00.04
Al9	00.14	00.14	00.13	00.21	00.04
Al10	00.06	00.09	00.13	00.04	00.17
...	...	...	...	...	...
Al45	00.09	00.05	00.17	00.13	00.22
Al46	00.28	00.14	00.03	00.17	00.13
Al47	00.14	00.18	00.13	00.08	00.22
Al48	00.28	00.05	00.10	00.17	00.09
Al49	00.14	00.05	00.17	00.21	00.22
Al50	00.09	00.14	00.17	00.13	00.22

b) Calculation of the Weighted Normalized Decision Matrix:

$$v_{ij} = w_j . r_{ij} \quad (4)$$

Vij= weight criteria to -j

rij= elements of the normalized decision matrix

Table 5. Calculation of the Weighted Normalized Decision Matrix

Alternative	Parental Income	Number of Dependents	GPA	Organizational Involvement	Non-Academic Achievements
Al1	0,02	0,04	0,05	0,01	0,02
Al2	0,02	0,02	0,05	0,03	0
Al3	0,07	0,03	0,04	0,01	0,01
Al4	0,04	0,03	0,04	0,03	0
Al5	0,07	0,02	0,05	0,03	0
Al6	0,02	0,02	0,05	0,02	0,01
Al7	0,02	0,01	0,03	0,02	0
Al8	0,02	0,05	0,04	0,01	0
Al9	0,04	0,03	0,04	0,03	0
Al10	0,02	0,02	0,04	0,01	0,02
...	...	...	...	...	...
Al45	0,02	0,01	0,05	0,02	0,02
Al46	0,07	0,03	0,01	0,03	0,01
Al47	0,04	0,04	0,04	0,01	0,02
Al48	0,07	0,01	0,03	0,03	0,01
Al49	0,04	0,01	0,05	0,03	0,02
Al50	0,02	0,03	0,05	0,02	0,02

c) Determination of Ideal Solutions:

1) Positive Ideal Solution (A^+):

A^+={max(v_{ij}) for benefit criteria, min(v_{ij}) for cost criteria}

2) Negative Ideal Solution (A^-):

A^-={min(v_{ij}) for benefit criteria, max(v_{ij}) for cost criteria}

	Ideal Positive (A^+)	Ideal Negative (A^-)
Parental Income (C1)	0,02	0,07
Number of Dependents (C2)	0,05	0,01
GPA (C3)	0,05	0,01
Organizational Involvement (C4)	0,03	0,01
Non-Academic Achievements (C5)	0,02	0

d) Calculation of Distance to Ideal Solutions:

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - A_j^+)^2} \quad (5)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - A_j^-)^2} \quad (6)$$

Alternative	Positif Distance to Ideal Solutions (D^+)	Negatif Distance to Ideal Solutions (D^-)
Al1	**0,022361**	**0,073485**
Al2	0,036056	0,067823
Al3	0,059161	0,037417
Al4	0,036056	0,05099
Al5	0,061644	0,045826
Al6	0,033166	0,066332
Al7	0,05	0,054772
Al8	0,03	0,070711
Al9	0,036056	0,05099
Al10	0,037417	0,06245
Al1	**0,04899**	**0,053852**
Al12	0,03	0,067823
Al13	0,053852	0,054772
Al14	0,031623	0,051962
Al15	0,05099	0,055678
Al16	0,056569	0,043589
Al17	0,05831	0,041231

e) Calculation of Preference Value:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (7)$$

Alternative	TOPSIS_Score
Al18	0,887311
Al23	0,887311
Al29	0,796132
Al28	0,77303
Al01	0,7667
Al41	0,7667
Al21	0,759747
Al50	0,759747
Al36	0,744603
Al34	0,73676
Al18	0,73676
Al23	0,728044
Al29	0,714867
Al28	0,71222
Al01	0,702117
Al41	0,693325
Al21	0,684338

TOPSIS is effective in ranking alternatives based on their proximity to ideal solutions and has been widely used in similar decision-support systems [10], [11]. Implementing the Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods in the scholarship selection process provided a robust framework for evaluating candidates based on multiple criteria. The evaluation was performed using five criteria: Parental Income (C1), Number of Dependents (C2), GPA (C3), Organizational Involvement (C4), and Achievements (C5), each assigned specific weights reflecting their importance in the selection process.

3.2.1 Comparison of SAW and TOPSIS Rankings

The comparison of rankings from SAW and TOPSIS methods revealed a high level of consistency, particularly for the top candidates:

The rankings generated by both methods identified the top candidates, as shown in Table 9 and Table 10, highlighting their respective scores and positions.

Table 6. Ranking Results Based on SAW

Rank	Alternative	SAW_Score
1	Al40	0,84
2	Al05	0,8
3	Al18	0,77
4	Al25	0,77
5	Al23	0,75
6	Al16	0,74
7	Al17	0,73
8	Al29	0,72
9	Al49	0,72
10	Al21	0,69

Table 7. Ranking Results Based on TOPSIS

Rank	Alternative	TOPSIS_Score (C_i)
1	Al18	0.887311
2	Al23	0.887311
3	Al29	0.796132
4	Al28	0.773030
5	Al01	0.766700
6	Al41	0.766700
7	Al21	0.759747
8	Al50	0.759747
9	Al36	0.744603
10	Al34	0.736760

3.2.2 Top Performers

3.2.2.1 Consistency Across Methods

Both SAW and TOPSIS identified Al18 and Al23 as the highest-ranking Candidates. Al18 scored 0.77 in SAW and achieved the highest TOPSIS score of 0.887311, indicating strong and consistent performance across all criteria. Al23 also ranked second in both methods, showcasing its balanced strength in key evaluation areas.

3.2.2.2 Shared High Rankings

Candidates Al18, Al23, Al29, and Al21 appeared in the top 10 of both methods, indicating agreement on their suitability for the scholarship.

3.2.3 Methodological Differences

1. SAW Focus on Aggregate Performance:
   a. SAW ranked Al40 as the top candidate with a score of 0.84, despite this candidate not appearing in the TOPSIS top 10. This highlights SAW's focus on the cumulative contribution of all criteria without considering relative proximity to ideal solutions.
   b. Candidates like Al05 and Al16, ranked 2nd and 6th in SAW, did not appear in TOPSIS's top rankings, suggesting their strong aggregate performance but less alignment with the ideal solution in TOPSIS.
2. TOPSIS Sensitivity to Trade-offs:

   TOPSIS identified candidates like Al28, Al50, and Al36, who did not rank in the SAW top 10. These candidates likely excelled in specific criteria aligned closely with the ideal positive solution, even if their aggregate scores were lower.
3. Ranking Variations in Lower Positions:

   Al49 ranked 9th in SAW with a score of 0.72 but did not appear in the TOPSIS top 10. Conversely, Al34, ranked 10th in TOPSIS with a score of 0.736760, was absent from SAW's top rankings.

3.2.4 Discussion

1. Strengths of Each Method:
    a. SAW is computationally efficient and provides a clear ranking based on aggregate performance, making it suitable for initial evaluations.
    b. TOPSIS offers a more nuanced evaluation by considering both ideal positive and negative solutions, making it better suited for capturing trade-offs between conflicting criteria.
2. Consistency and Reliability:

Identifying top candidates like Al18 and Al23 in both methods validates the reliability of the evaluation framework. These candidates consistently performed well across multiple criteria.

3. Practical Implications for Decision-Making:
    a. Decision-makers can rely on SAW to quickly filter candidates and use TOPSIS to refine the final selection by evaluating relative proximity to ideal performance.
    b. Alidates appearing in the top rankings of both methods, such as Al18, Al23, and Al29, should be prioritized for scholarship allocation due to their consistent performance.

4. Conclusion

The comparison highlights the complementary nature of SAW and TOPSIS methods. While SAW emphasizes aggregate performance, TOPSIS evaluates candidates based on their alignment with the ideal solution. These methods provide a comprehensive and transparent framework for scholarship selection, ensuring that consistent performers and candidates with specialized strengths are identified. This dual-method approach enhances the fairness and accuracy of the decision-making process.

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