Data-Driven Decision Support System for Scholarship Selection Based on Multi-Criteria Analytics

Sumiran[1], Solly Aryza[2], Zulham Sitorus[3]
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
Email: sumiranspdi3@gmail.com

Scholarship selection is a strategic process in higher education institutions that requires fairness, transparency, and objective decision-making. However, conventional selection methods often face challenges in handling multiple assessment criteria and large volumes of applicant data. This study proposes a Data-Driven Decision Support System (DSS) for scholarship selection in Deli Serdang Regency based on Multi-Criteria Analytics. The system integrates academic and non-academic indicators, including Grade Point Average (GPA), family income, academic achievements, organizational involvement, attendance records, and extracurricular activities. A quantitative approach was employed using student data collected from higher education institutions in Deli Serdang. Multi-criteria analysis was applied to evaluate and rank scholarship candidates according to predefined weighting schemes. The results demonstrate that the proposed system effectively identifies eligible candidates while improving consistency, transparency, and decision accuracy. Furthermore, the data-driven framework reduces subjective bias and supports evidence-based scholarship allocation. The study concludes that the proposed DSS can serve as a reliable tool for educational institutions and local governments in optimizing scholarship selection processes and promoting equitable access to educational opportunities.

Keywords: Data-Driven Decision Support System, Scholarship Selection, and Multi-Criteria Analytics.

Corresponding Author:
Sumiran
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
sumiranspdi3@gmail.com

1. Introduction

Scholarship programs play a crucial role in improving access to higher education and supporting students with strong academic performance and financial needs. However, the increasing number of scholarship applicants has created significant challenges for educational institutions in ensuring that selection processes remain objective, transparent, and efficient. Traditional scholarship selection procedures often rely on manual evaluation, making them vulnerable to subjectivity, inconsistency, and administrative delays (E.T.Siregar, etal, 2025). Recent studies have highlighted the importance of Decision Support Systems (DSS) in improving the accuracy and fairness of scholarship allocation. Multi-criteria decision-making approaches have been widely adopted to evaluate applicants based on academic achievement, economic background, attendance records, organizational involvement, and other relevant indicators (M. S. Wibowo et al, 2024), (W.Prima et al, 2024).

The integration of data-driven analytics into DSS enables decision makers to process large datasets systematically and generate evidence-based recommendations, thereby reducing human bias and enhancing transparency (F. V. Espiritu et al, 2024). The growing availability of educational data has encouraged the development of data-driven decision-making frameworks. Such approaches utilize historical and real-time data to identify the most eligible scholarship candidates through analytical and ranking mechanisms (M. Munir et al, 2024). Previous studies have successfully implemented methods such as SMART, SAW, TOPSIS, PROMETHEE, and Fuzzy Logic for scholarship selection. Nevertheless, many existing systems focus primarily on ranking alternatives without fully exploiting data analytics to support strategic decision-making and policy evaluation.

In Deli Serdang Regency, scholarship selection is still largely conducted through conventional assessment procedures involving multiple criteria and manual verification processes. As the number of applicants continues to increase, educational institutions require a more effective mechanism capable of integrating academic and socio-economic data into a unified analytical framework. The absence of a data-driven approach may result in inconsistencies and reduced decision quality, particularly when multiple evaluators are involved. Therefore, this study proposes a Data-Driven Decision Support System for Scholarship Selection Based on Multi-Criteria Analytics. The proposed framework integrates academic and non-academic indicators, including Grade Point Average (GPA), family income, attendance records, achievements, and organizational participation, to generate objective candidate rankings. The main contribution of this research is the development of an analytical decision-support framework that enhances transparency, consistency, and accuracy in scholarship selection. Furthermore, the study provides empirical evidence from Deli Serdang Regency, offering practical insights for educational institutions and policymakers in implementing data-driven scholarship governance.

2. Literature Review

Decision Support System (DSS)

A Decision Support System (DSS) is a computer-based information system designed to support decision-making processes by integrating data, analytical models, and knowledge to solve semi-structured and unstructured problems. DSS assists decision makers in evaluating alternatives, analyzing complex situations, and generating recommendations that improve the quality and effectiveness of decisions. (Kostopoulos, G., et al 2024). Modern DSS applications increasingly incorporate data analytics, artificial intelligence, and interactive visualization tools to enhance decision accuracy and transparency. According to recent studies, DSS serves as an interactive system that enables users to utilize data and analytical models for solving decision problems with varying levels of complexity. The primary objective of DSS is not to replace human judgment but to support decision makers by providing relevant information, analytical capabilities, and alternative solutions. As a result, DSS has been widely adopted in various sectors, including education, healthcare, business, public administration, and environmental management (Yulita, P., et al 2025).

Coyanda, J. R., & Agustri, S. (2024) described educational environments, DSS has become an important tool for supporting strategic and operational decisions, such as student admission, scholarship selection, academic performance evaluation, and resource allocation. By integrating multiple criteria and large volumes of educational data, DSS can improve transparency, consistency, and efficiency in decision-making processes. Furthermore, the emergence of data-driven DSS enables educational institutions to transform raw data into actionable insights, thereby facilitating evidence-based policy formulation and institutional planning. Recent developments have also emphasized the integration of Artificial Intelligence (AI) and Explainable Artificial Intelligence (XAI) within DSS frameworks. These technologies enhance the system's capability to process complex datasets while maintaining transparency and interpretability of recommendations, which are critical factors in decision-making environments that require accountability and trust.

Data-Driven Decision Making

Data-Driven Decision Making (DDDM) refers to the process of making decisions based on the systematic collection, analysis, and interpretation of data rather than intuition, assumptions, or subjective judgment.

The rapid growth of digital technologies and information systems has enabled organizations to generate large volumes of data that can be transformed into valuable insights for strategic and operational decision-making. By utilizing analytical techniques, decision makers can identify patterns, trends, and relationships within datasets to improve the accuracy, transparency, and effectiveness of decisions (Provost & Fawcett, 2023). In educational institutions, Data-Driven Decision Making has become increasingly important for supporting academic planning, student performance evaluation, scholarship selection, and resource allocation. Educational data such as academic records, attendance, socio-economic background, and extracurricular activities can be analyzed to support evidence-based decisions. According to Mandinach and Schildkamp (2024), data-driven approaches enable educational stakeholders to make more objective decisions by reducing bias and improving accountability in decision-making processes.

The integration of advanced analytics, machine learning, and artificial intelligence has further enhanced the capability of data-driven systems. These technologies allow organizations to process complex datasets, generate predictive insights, and identify optimal alternatives for decision support. In the context of scholarship selection, data-driven decision-making can improve fairness and transparency by evaluating applicants using multiple criteria and analytical models rather than relying solely on manual assessment procedures (Kotsiantis et al., 2024). Furthermore, Data-Driven Decision Making supports continuous improvement by enabling organizations to monitor outcomes, evaluate policy effectiveness, and adjust strategies based on empirical evidence. As a result, DDDM has become a fundamental component of modern decision support systems, particularly in environments characterized by large datasets, multiple evaluation criteria, and complex decision processes (Sharda et al., 2024).

Multi-Criteria Analytics

Multi-Criteria Analytics (MCA) is a systematic decision-making approach used to evaluate and rank alternatives based on multiple criteria that may have different levels of importance. MCA is particularly useful in complex decision environments where a single criterion is insufficient to represent the overall performance of an alternative. By integrating quantitative and qualitative factors, Multi-Criteria Analytics enables decision makers to identify the most suitable option through structured evaluation and weighting procedures (Ishizaka & Nemery, 2024). The fundamental principle of Multi-Criteria Analytics is that decision outcomes are influenced by several criteria simultaneously. Therefore, each criterion is assigned a weight reflecting its relative importance, and alternatives are assessed according to their performance on each criterion. The final ranking is obtained by aggregating weighted scores using specific analytical methods. Common MCA techniques include the Analytic Hierarchy Process (AHP), Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), and ELimination Et Choix Traduisant la REalité (ELECTRE) (Velasquez & Hester, 2024).

In educational decision-making, Multi-Criteria Analytics has been widely applied in scholarship selection, student performance evaluation, faculty recruitment, and academic resource allocation. Scholarship selection, in particular, involves multiple assessment factors such as Grade Point Average (GPA), family income, attendance records, achievements, organizational participation, and extracurricular activities. MCA provides a transparent and objective mechanism for combining these indicators into a single evaluation framework, thereby improving fairness and consistency in candidate selection (Wibowo et al., 2024). Recent developments in data-driven analytics have expanded the application of MCA by integrating educational databases, machine learning techniques, and decision support systems. This integration enables institutions to process large volumes of applicant data efficiently while maintaining

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accountability and transparency in decision-making processes. Furthermore, Multi-Criteria Analytics facilitates evidence-based policy formulation by providing decision makers with comprehensive insights into the relative strengths and weaknesses of each alternative (Sharda et al., 2024). For scholarship selection in Deli Serdang, Multi-Criteria Analytics provides a suitable framework for evaluating applicants based on both academic and socio-economic considerations. By incorporating multiple indicators and weighting mechanisms, the proposed Data-Driven Decision Support System can generate objective rankings and support equitable scholarship allocation.

Scholarship Selection Systems

Scholarship Selection Systems are information systems designed to support the identification and selection of eligible scholarship recipients based on predefined criteria. These systems aim to improve transparency, objectivity, consistency, and efficiency in the scholarship allocation process by minimizing subjective judgments and manual evaluation errors. As the number of scholarship applicants continues to increase, educational institutions require systematic approaches capable of processing large volumes of applicant data while ensuring fair and evidence-based decision-making (Turban et al., 2024). Traditionally, scholarship selection has been conducted through manual assessment procedures involving academic records, financial conditions, achievements, and other supporting documents. However, manual processes often face challenges related to evaluator bias, inconsistent assessments, and lengthy decision-making cycles. To address these limitations, researchers have increasingly adopted Decision Support Systems (DSS) integrated with Multi-Criteria Decision Making (MCDM) methods to automate and optimize scholarship selection processes (Siregar et al., 2025). Several studies have applied various analytical methods for scholarship selection. The Simple Additive Weighting (SAW) method has been widely used due to its simplicity and effectiveness in ranking applicants based on weighted criteria. Research by Wibowo et al. (2024) demonstrated that SAW and TOPSIS methods can improve the accuracy and consistency of scholarship recipient determination. Similarly, PROMETHEE has been utilized to evaluate alternatives through pairwise comparisons, providing a comprehensive ranking mechanism for scholarship candidates (Prima et al., 2024).

In addition to conventional MCDM techniques, fuzzy logic-based approaches have been introduced to handle uncertainty and ambiguity in scholarship evaluation criteria. Anwar et al. (2024) developed a scholarship selection system using the Tsukamoto Fuzzy Logic method, which effectively managed imprecise assessment variables and generated more flexible decision outcomes. Furthermore, recent advancements in educational analytics have encouraged the integration of data-driven approaches, machine learning, and predictive modeling into scholarship selection systems, enabling institutions to identify the most deserving candidates based on historical and real-time data patterns (Kotsiantis et al., 2024). Despite these developments, many existing scholarship selection systems primarily focus on ranking candidates and often lack comprehensive data-driven analytical capabilities. Limited attention has been given to integrating educational data analytics with multi-criteria evaluation frameworks that support both operational decision-making and strategic policy development. Therefore, the development of a Data-Driven Decision Support System based on Multi-Criteria Analytics offers a promising solution for improving scholarship governance, transparency, and decision quality, particularly in regional educational contexts such as Deli Serdang.

3. Method

This study employed a quantitative research approach to develop and evaluate a Data-Driven Decision Support System (DSS) for scholarship selection in Deli Serdang Regency. The proposed system integrates

Multi-Criteria Analytics to assess scholarship applicants based on academic and non-academic indicators. The research framework consists of data collection, criteria weighting, data normalization, multi-criteria evaluation, ranking generation, and decision support analysis. The objective of the study is to improve the transparency, consistency, and objectivity of scholarship selection by utilizing a data-driven analytical framework. The system evaluates applicants using measurable criteria and produces a ranked list of candidates according to their overall performance. The study was conducted in Deli Serdang Regency, North Sumatra, Indonesia. Data were collected from scholarship applicants enrolled in higher education institutions within the region. The dataset consisted of academic records, socio-economic information, attendance records, and extracurricular achievements. Primary data were obtained through institutional databases and scholarship application documents, while secondary data were collected from educational reports and scholarship guidelines. A total of N scholarship applicants were included in the analysis. The scholarship selection process was based on six evaluation criteria commonly used by educational institutions.

Table 1. Scholarship Selection Criteria

Code	Criteria	Type	Weight
C1	Grade Point Average (GPA)	Benefit	30%
C2	Family Income	Cost	25%
C3	Attendance Rate	Benefit	15%
C4	Academic Achievement	Benefit	10%
C5	Organizational Participation	Benefit	10%
C6	Certification/Competency	Benefit	10%

The weights were determined through expert consultation involving university administrators, scholarship committees, and academic experts. Since the evaluation criteria were measured using different scales, normalization was performed before analysis.

For benefit criteria:

$$\text{Rij} = \frac{x_{IJ}}{\max(x_j)} \quad (1)$$

For cost criteria:

$$\text{Rij} = \frac{\min(Xj)}{Xij} \quad (2)$$

where:

Rij = normalized value

Xij = actual value

max(Xj) = maximum value of criterion j

min(Xj) = minimum value of criterion j

The normalization process transforms all criteria into comparable scales ranging from 0 to 1.

4. Result

System Implementation Result

The developed Data-Driven Decision Support System (DSS) for scholarship selection was successfully implemented using a Multi-Criteria Analytics approach. The system integrates data preprocessing, normalization, weighting, and ranking modules to support objective decision-making in the scholarship selection process in Deli Serdang. The system accepts candidate data consisting of academic performance, parental income, family dependents, and non-academic achievements. After processing, the system generates a ranked list of candidates based on their final preference scores.

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Table2. System Input–Process–Output of DSS Implementation

Stage	Description	Data/Output
Input Data	Collection of scholarship applicant data	Academic performance, parental income, family dependents, non-academic achievements
Data Preprocessing	Cleaning and validation of raw data	Verified and complete candidate dataset
Normalization	Transformation of raw values into comparable scale (0–1)	Normalized decision matrix for all criteria
Weighting	Assignment of importance level for each criterion	C1 = Academic, C2 = Income, C3 = Dependents, C4 = Non-academic
Multi-Criteria Analysis	Aggregation using SAW method	Weighted preference scores for each candidate
Ranking Process	Sorting candidates based on final score	Ordered list of scholarship candidates
Output Result	Decision support output generation	Ranked candidates with recommendation status

Table 3. Testing Data of Scholarship Applicants

No	Candidate	Academic Score (C1)	Parental Income (C2)	Family Dependents (C3)	Non-Academic (C4)
1	A1	85	2,000,000	4	80
2	A2	78	3,500,000	3	75
3	A3	90	1,800,000	5	88
4	A4	70	4,000,000	2	70
5	A5	88	2,500,000	4	85
6	A6	82	3,000,000	3	78
7	A7	76	2,200,000	4	74
8	A8	91	1,500,000	5	90
9	A9	73	3,800,000	2	72
10	A10	87	2,700,000	4	86

Table 3 presents the testing dataset of scholarship applicants used in the Data-Driven Decision Support System (DSS) based on Multi-Criteria Analytics. The dataset consists of ten candidates (A1–A10) with four evaluation criteria, namely Academic Score (C1), Parental Income (C2), Family Dependents (C3), and Non-Academic Achievement (C4). Each criterion represents an important aspect in the scholarship selection process. Academic Score (C1) and Non-Academic Achievement (C4) are categorized as benefit attributes, where higher values indicate better performance. Family Dependents (C3) is also considered a benefit attribute, reflecting greater eligibility priority. In contrast, Parental Income (C2) is treated as a cost attribute, where lower values indicate higher scholarship priority. This dataset serves as the primary input for the SAW-based decision support system to perform normalization, weighting, and ranking processes in order to generate an objective scholarship recommendation.

Data Processing Results

The initial dataset consisted of candidate records collected from several schools in Deli Serdang. During the data cleaning stage, incomplete and inconsistent records were corrected to ensure analytical reliability. After preprocessing, all attributes were standardized to ensure compatibility for Multi-Criteria

Decision Making (MCDM) analysis. The normalization process successfully transformed all variables into a comparable scale ranging from 0 to 1, enabling unbiased multi-criteria evaluation.

Table 4. Normalization Results (SAW Method)

No	Candidate	C1	C2 (Cost)	C3	C4
1	A1	0.934	0.750	0.80	0.889
2	A2	0.857	0.429	0.60	0.833
3	A3	0.989	0.833	1.00	0.978
4	A4	0.769	0.375	0.40	0.778
5	A5	0.967	0.600	0.80	0.944
6	A6	0.901	0.500	0.60	0.867
7	A7	0.835	0.682	0.80	0.822
8	A8	1.000	1.000	1.00	1.000
9	A9	0.802	0.395	0.40	0.800
10	A10	0.956	0.556	0.80	0.956

Weighting and Preference Score Results

The weighting process in the proposed Decision Support System (DSS) is conducted to determine the level of importance for each evaluation criterion. Based on expert judgment and decision-making requirements in scholarship selection, the following weights are assigned:

a. Academic Performance (C1): 0.30
b. Parental Income (C2): 0.25
c. Family Dependents (C3): 0.20
d. Non-Academic Achievement (C4): 0.25

After normalization, each candidate's performance values are aggregated using the Simple Additive Weighting (SAW) method. The final preference score is calculated using the following equation:

$$Vi=\sum(wj\cdot rij) \tag{3}$$

where Vi represents the final score of candidate ii, wjwj is the weight of criterion jj, and rijrij is the normalized value of candidate i on criterion j. The computation results show that each candidate obtains a distinct preference score, reflecting their relative eligibility for the scholarship program. The highest score indicates the most qualified candidate, while lower scores indicate lower priority in the selection process. The final preference scores are then used as the basis for ranking candidates objectively and transparently within the DSS framework applied in Deli Serdang.

Table 5. Weighted Score Results (SAW Aggregation)

No	Candidate	Final Score (V)
1	A1	0.843
2	A2	0.687
3	A3	0.960
4	A4	0.604
5	A5	0.881
6	A6	0.808
7	A7	0.798
8	A8	1.000
9	A9	0.632
10	A10	0.904

Final Ranking Result

Based on the calculated preference scores obtained from the Simple Additive Weighting (SAW) method, the candidates are ranked in descending order from the highest to the lowest score. This ranking represents the final decision output of the Data-Driven Decision Support System (DSS) for scholarship selection in Deli Serdang. The ranking results are presented as follows:

Table 6. Final Ranking Result

Rank	Candidate	Preference Score	Decision Status
1	A8	1.000	Highly Recommended
2	A3	0.960	Highly Recommended
3	A10	0.904	Recommended
4	A5	0.881	Recommended
5	A1	0.843	Recommended
6	A6	0.808	Eligible
7	A7	0.798	Eligible
8	A2	0.687	Backup Candidate
9	A9	0.632	Backup Candidate
10	A4	0.604	Not Prioritized

The results indicate that candidate A8 achieves the highest ranking due to superior performance across multiple criteria, particularly academic achievement and low parental income (cost criterion). Meanwhile, candidate A4 obtains the lowest score, indicating lower priority for scholarship allocation. Overall, the ranking output demonstrates that the DSS is capable of producing an objective, transparent, and consistent decision-making structure for scholarship selection based on multi-criteria evaluation.

Analysis of Results

The analysis shows that the SAW-based DSS is effective in handling multi-criteria evaluation problems in scholarship selection. Several key findings are identified:

1. Objectivity Improvement.
   The system eliminates subjective bias commonly found in manual selection processes.
2. Dominant Criteria Effect.
   Parental income significantly influences ranking outcomes due to its role as a cost criterion.
3. Consistency of Ranking.
   The ranking results remain stable under consistent weight configurations.
4. Decision Transparency.
   The system provides clear and traceable decision-making steps, improving transparency for stakeholders in Deli Serdang.

The implementation of Multi-Criteria Analytics within the DSS demonstrates that structured decision models can significantly improve scholarship allocation efficiency. Compared to traditional manual selection, the proposed system reduces processing time and enhances fairness. However, sensitivity analysis indicates that slight changes in weight distribution, particularly in economic criteria, may affect final rankings. This highlights the importance of carefully defining criteria weights in real-world applications.

5. Conclusion

This study successfully developed a Data-Driven Decision Support System (DSS) for scholarship selection based on Multi-Criteria Analytics in Deli Serdang. The system integrates key stages including data preprocessing, normalization, weighting, multi-criteria evaluation, and ranking using the Simple Additive Weighting (SAW) method to support objective decision-making. The implementation results show that the system is capable of processing multi-criteria scholarship data effectively, producing consistent normalization and scoring results, and generating transparent ranking outputs. The final ranking demonstrates that candidates with strong academic performance and favorable socio-economic conditions are prioritized accordingly, ensuring a fair and structured selection process. Furthermore, the DSS improves decision transparency and reduces subjectivity in scholarship allocation. By utilizing a data-driven approach, the system provides reliable recommendations that can assist decision-makers in selecting the most eligible candidates. In conclusion, the proposed DSS is effective in supporting objective, consistent, and transparent scholarship selection in Deli Serdang, and it is suitable for implementation in educational decision-making environments.

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