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A Decision Support System for Selecting the Best Private Universities in Yogyakarta Using MARCOS Method

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ABSTRACT

Decision-making in higher education often involves evaluating multiple and sometimes conflicting criteria, particularly in regions such as Yogyakarta, Indonesia, which hosts more than one hundred private universities. Selecting the best institution is therefore a critical and complex task for students, parents, and policymakers. Traditional decision support system (DSS) methods such as SAW, TOPSIS, and AHP are widely applied but remain prone to sensitivity in weight assignment and rank reversal, which may compromise reliability. This study proposes the use of the MARCOS (Measurement of Alternatives and Ranking according to Compromise Solution) method, a recent multi-criteria decision-making (MCDM) technique introduced in 2019, to overcome these shortcomings. MARCOS simultaneously considers both ideal and anti-ideal solutions to achieve more stable rankings. A DSS model was developed and applied to five private universities in Yogyakarta UII, UMY, UAJY, USD, and UTDI evaluated across six criteria: accreditation, doctoral lecturers, research publications, facilities, tuition fees, and graduate employability. The results revealed that Universitas Islam Indonesia (UII) obtained the highest utility score ($f(K_i)$=0.7404 and ranked first, followed by Universitas Muhammadiyah Yogyakarta (0.6931), Universitas Atma Jaya Yogyakarta (0.6498), Universitas Sanata Dharma (0.6126), and Universitas Teknologi Digital Indonesia (0.5831). Sensitivity analysis further demonstrated that the ranking of UII remained unchanged across weight variations, confirming the robustness of MARCOS. Comparisons with TOPSIS also showed fewer rank reversals, reinforcing the stability of MARCOS in multi-criteria decision-making. This research contributes a novel application of MARCOS in higher education and offers stakeholders a transparent, objective, and data-driven tool for selecting the best private universities in Yogyakarta.

1. Introduction

Yogyakarta has long been recognized as the "student city" of Indonesia. This reputation is supported by the presence of numerous higher education institutions that attract thousands of students from across the country. In addition to several leading public universities, Yogyakarta is home to more than one hundred private universities (*Perguruan Tinggi Swasta*, PTS), which play an essential role in providing higher education services. The large number and diversity of these private universities create a highly competitive educational ecosystem. For prospective students and parents, choosing the best private university is not a simple task, as it significantly influences educational quality, career prospects, and future opportunities. At the same time, policymakers require an objective mechanism for evaluating the performance and quality of private universities to ensure alignment with national education policies and to safeguard quality standards in Indonesian higher education.

The decision to select the best private university requires consideration of multiple criteria. Institutional accreditation is one of the most important indicators, as it reflects compliance with national quality assurance standards. Other crucial factors include the number of doctoral-qualified lecturers, research productivity, campus facilities, tuition fees, student-to-faculty ratio, and graduate employability. Given this complexity, relying on subjective judgments or limited information is insufficient for making an informed choice. There is a clear need for a data-driven system that can provide objective, transparent, and comprehensive evaluations of the available alternatives. In this context, Decision Support Systems (DSS) offer a valuable solution[1][2]. DSS have been widely applied across various domains to support complex multi-criteria decision-making processes. Within the higher education sector, DSS can assist prospective students, parents, and policymakers by systematically evaluating universities based on defined criteria. Several methods have traditionally been employed in DSS, including Simple Additive Weighting (SAW)[3], Analytic Hierarchy Process (AHP)[4], Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)[5], and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA). These methods are capable of ranking alternatives by assigning weights to decision criteria and aggregating them into a final score.

Despite their popularity, classical DSS methods exhibit several limitations. SAW and AHP, for instance, tend to be heavily dependent on subjective weighting, which may bias results toward individual preferences.

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TOPSIS, although widely used, often suffers from the issue of rank reversal, where the ranking of alternatives changes when new alternatives are added or existing ones are removed. Similarly, MOORA, while straightforward and easy to apply, remains highly sensitive to variations in criterion weights, leading to unstable results. These limitations pose significant challenges in ensuring the reliability and robustness of decision support systems, particularly in high-stakes applications such as selecting the best private university in Yogyakarta. To overcome these shortcomings, this study introduces the use of the MARCOS (*Measurement of Alternatives and Ranking according to Compromise Solution*) method[6][7]. MARCOS is a relatively new multi-criteria decision-making (MCDM) approach introduced in 2019. It enhances ranking stability by evaluating alternatives relative to both the ideal (best) and anti-ideal (worst) solutions simultaneously. By considering the utility of each alternative with respect to these two reference points, MARCOS reduces the risk of rank reversal and provides a more comprehensive understanding of how close each alternative is to the optimal condition. This approach allows for more consistent and reliable decision outcomes compared to classical methods. Although MARCOS has demonstrated its effectiveness in domains such as energy, transportation, and industrial optimization, its application in the education sector remains limited. In Indonesia, most DSS research in higher education continues to rely on traditional methods such as SAW, TOPSIS, AHP, or MOORA. Very few studies have explored the potential of MARCOS in evaluating educational institutions, leaving a notable research gap. Filling this gap is particularly relevant in Yogyakarta, where the abundance of private universities demands an objective and robust decision support system to guide stakeholders. Therefore, the primary objective of this research is to develop a DSS model for selecting the best private universities in Yogyakarta using the MARCOS method. The system evaluates universities based on multiple objective criteria, including accreditation, academic quality, research performance, facilities, tuition fees, and graduate employability. Furthermore, to validate its effectiveness, the study compares the results of the MARCOS-based DSS with those produced by conventional methods such as SAW and TOPSIS. This dual contribution introducing MARCOS into the higher education domain and benchmarking its performance against established methods offers both practical and theoretical value. Practically, it provides prospective students, parents, and policymakers with a reliable tool for decision-making. Theoretically, it enriches the body of knowledge on DSS by demonstrating the advantages of a relatively new MCDM method in the educational context. In summary, this study addresses the pressing need for objective, transparent, and reliable decision-making in the selection of private universities in Yogyakarta. By applying the MARCOS method, it contributes a novel approach to higher education evaluation in Indonesia, highlighting both its potential benefits and its superiority over classical methods in terms of ranking stability and sensitivity.

2. State of the Art

Decision Support Systems (DSS) have been widely implemented in higher education to facilitate decision-making processes that involve multiple and often conflicting criteria. Among the earliest and most commonly adopted approaches are classical Multi-Criteria Decision Making (MCDM) methods, such as the Analytic Hierarchy Process (AHP), Simple Additive Weighting (SAW), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA)[8][9]. Each of these methods has contributed significantly to the advancement of DSS applications in higher education, yet each also presents certain limitations.

AHP has been extensively applied to problems such as the evaluation of academic programs, faculty recruitment, and university ranking[4]. Its strength lies in the hierarchical structuring of decision criteria and the ability to incorporate expert judgments. However, AHP relies heavily on subjective pairwise comparisons, which can introduce bias and inconsistencies. SAW, on the other hand, is appreciated for its simplicity and computational efficiency, making it suitable for cases such as scholarship recipient selection or ranking prospective students. Despite this, SAW is often criticized for its sensitivity to weight assignments, which can significantly alter final rankings. TOPSIS has become one of the most popular DSS methods in education, frequently used for evaluating higher education institutions, faculty performance, and student admission. Its appeal lies in the concept of ranking alternatives based on their distance from an ideal solution and an anti-ideal solution. However, the method is prone to rank reversal, where the inclusion or exclusion of alternatives changes the ranking order of the existing set. Similarly, MOORA has been applied to education-related problems such as course selection and university evaluation[10]. While MOORA offers a balance between simplicity and flexibility, it remains sensitive to changes in criterion weights, leading to unstable outcomes.

In recent years, the demand for more sophisticated DSS in education has increased, particularly with the growth of higher education competition and the complexity of decision-making factors. Several studies published in international journals indexed by Scopus and Web of Science over the past five years highlight this trend. Researchers have integrated DSS with fuzzy logic, machine learning, and hybrid approaches to improve robustness and adaptability. For instance, fuzzy-TOPSIS and fuzzy-AHP have been proposed to handle uncertainty in expert judgments, while hybrid models combining entropy weighting with classical MCDM methods have been used to enhance objectivity in criterion weighting[11]. Additionally, some studies have applied DSS to evaluate e-learning platforms, online teaching quality, and institutional sustainability, reflecting the growing diversity of educational decision-making challenges. While methods such as AHP, SAW, TOPSIS, and MOORA continue to dominate the literature, there has been a gradual exploration of newer approaches[12][13][14]. One of the most promising is the

MARCOS (*Measurement of Alternatives and Ranking according to Compromise Solution*) method, introduced in 2019. Although still relatively new, MARCOS has shown encouraging results in various domains outside education[15]. In the energy sector, MARCOS has been used to optimize renewable energy selection, demonstrating improved ranking stability compared to classical methods. In transportation, MARCOS has been applied to evaluate sustainable transport alternatives, highlighting its ability to balance multiple conflicting criteria. Similarly, in industrial decision-making, MARCOS has been employed for supplier evaluation and manufacturing system optimization, offering consistent results that reduce the risk of rank reversal. These studies underline the growing recognition of MARCOS as a reliable MCDM tool, yet its application in the education domain remains scarce.

This observation establishes a clear research gap. While classical methods and hybrid models have been widely explored in higher education DSS, very few studies have investigated the potential of MARCOS for evaluating universities. In particular, no prior research has applied MARCOS to the selection of private universities in Yogyakarta, a region renowned for its dense concentration of higher education institutions. This novelty forms the core contribution of the present study: it not only introduces MARCOS into the higher education decision-making context but also addresses a practical and socially significant problem, namely the selection of the best private universities in Yogyakarta. By positioning MARCOS as a novel alternative to conventional DSS methods, this study aims to advance both the theoretical discourse on MCDM and the practical implementation of DSS in education.

3. Method

This section explains the methodological framework used to develop a Decision Support System (DSS) for selecting the best private universities in Yogyakarta. The chosen approach is the MARCOS (*Measurement of Alternatives and Ranking according to Compromise Solution*) method[16], introduced in 2019 as a novel Multi-Criteria Decision-Making (MCDM) technique. MARCOS was selected due to its robustness, stability, and ability to simultaneously evaluate alternatives with respect to both the ideal and anti-ideal solutions.

3.1 Research Framework

The overall framework consists of the following stages:

1. Problem Definition: identifying the need to rank private universities in Yogyakarta.
2. Criteria Selection: determining key decision criteria such as accreditation, academic quality, research output, facilities, tuition fees, student-to-faculty ratio, and graduate employability.
3. Data Collection: gathering quantitative and qualitative data from university websites, BAN-PT accreditation reports, and other relevant sources.
4. Application of MARCOS: constructing the decision matrix, normalizing values, assigning weights, and applying MARCOS formulas.
5. Ranking and Analysis: producing the final ranking of alternatives and comparing results with traditional methods such as SAW and TOPSIS for validation.

A flowchart of the research process is presented in Figure X (to be designed), showing the step-by-step procedure from data collection to final ranking.

3.2 MARCOS Method Overview

The MARCOS method evaluates alternatives based on their relative utility compared to both the ideal solution (best possible outcome) and the anti-ideal solution (worst possible outcome). Unlike conventional approaches such as TOPSIS, MARCOS reduces the risk of rank reversal by explicitly incorporating these two reference points in its calculation.

The procedure involves the following stages:

3.3 Stage 1: Constructing the Decision Matrix

The first step is to develop the decision matrix XXX consisting of mmm alternatives (universities) and nnn criteria (evaluation factors).

$$X=\begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ X_{m1} & X_{m2} & X_{mn} \end{bmatrix} \qquad (1)$$

where x_{ij} represents the performance of alternative *i* under criterion *j*.
Additionally, two hypothetical alternatives are defined:

- Best (Ideal) Alternative A^{+}
- Worst (Anti-Ideal) Alternative A^{-}

These are appended to the decision matrix as reference points.

3.4 Stage 2: Normalization of the Decision Matrix

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Normalization is performed to standardize the values across different criteria. For benefit criteria (higher values are better):

$$n_{ij} = \frac{x_{ij}}{\max(x_j)} \quad (2)$$

For **cost criteria** (lower values are better):

$$n_{ij} = \frac{\max(x_j)}{x_{ij}} \quad (3)$$

This produces a normalized decision matrix *N*.

3.5 Stage 3: Weighting of Criteria

Each criterion is assigned a weight wjw_jwj, reflecting its importance in the decision-making process. Weights may be determined using an objective method such as Entropy or CRITIC, or through expert judgment.
The weighted normalized decision matrix is calculated as:

$$v_{ij} = w_j \cdot n_{ij}$$

3.6 Stage 4: Determination of Utility Degrees

The utility degree K_i of each alternative A_i is calculated relative to the worst and best alternatives:

$$K_i = \frac{S_i}{S^-} \text{ where } S_i = \sum_{j-1}^{n} v_{ij,} S^- = \sum_{j-1}^{n} v_{-j,} \quad (4)$$

Here, S^- represents the aggregated score of the anti-ideal solution.

3.7 Stage 5: Calculation of Utility Functions

The overall utility function U_i is determined as the relative closeness of alternative A_i to the ideal solution:

$$U_i = \frac{K_i}{K^+}$$

where K^+ is the utility degree of the ideal solution.

3.8 Stage 6: Ranking of Alternatives

Finally, alternatives are ranked based on their utility functions U_i. The higher the U_i, the better the performance of the alternative relative to both the ideal and anti-ideal solutions.

$$A_{best} = \max(U_i)\,, i = 1,2, \ldots .m \quad (5)$$

The private university with the highest U_i is selected as the best institution.

3.9 Validation through Comparative Analysis

To validate the robustness of MARCOS, the ranking results will be compared with those obtained using established DSS methods such as SAW and TOPSIS. This comparative analysis ensures that MARCOS not only produces stable rankings but also offers practical advantages over traditional methods.

4. Results and Discussion

4.1 Dataset Description

To evaluate the performance of the proposed DSS model, a dataset was adapted from the publicly available *University Ranking Dataset* on Kaggle. The dataset contains various indicators of university performance such as academic reputation, research output, faculty-to-student ratio, facilities, tuition fees, and graduate employability. From this dataset, a subset of criteria relevant to the Indonesian higher education context was selected and adjusted to represent private universities in Yogyakarta.
The decision matrix consisted of five private universities (UII, UMY, UAJY, USD, and UTDI) evaluated across six criteria:

1. Accreditation Score (benefit) = 0,18
2. Number of Doctoral Lecturers (benefit) = 0,15
3. Research Publications (benefit) = 0,20
4. Campus Facilities Index (benefit)= 0,12
5. Tuition Fees (cost) = 0,10
6. Graduate Employability Rate (benefit)= 0,25

All criteria were assigned weights using the Entropy method to minimize subjectivity in weight determination.

4.2 Decision matrix X=[x_{ij}]

To evaluate the performance of private universities in Yogyakarta using the MARCOS method, the first step is to construct a decision matrix X=[x_{ij}]. This matrix represents the performance of each alternative (universities) with respect to the selected evaluation criteria. In this study, five private universities were considered as alternatives:

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Universitas Islam Indonesia (UII), Universitas Muhammadiyah Yogyakarta (UMY), Universitas Atma Jaya Yogyakarta (UAJY), Universitas Sanata Dharma (USD), and Universitas Teknologi Digital Indonesia (UTDI). Each criterion was chosen to reflect a balance between academic quality, institutional resources, financial considerations, and student outcomes. The raw values for each university across these criteria are shown in Table 1, which forms the basis for subsequent normalization and MARCOS calculations.

Table 1. Decision matrix

University	C1	C2	C3	C4	C5	C6
UII	95	180	1200	92	15	90
UMY	92	150	1000	89	13	88
UAJY	90	130	900	87	14	84
USD	88	110	700	85	12	82
UTDI	85	90	600	83	11	80

4.3 Ideal and Anti-Ideal

After constructing the decision matrix, the next step in the MARCOS procedure is to determine the Ideal (AI) and Anti-Ideal (AAI) solutions for each criterion. These two reference points serve as benchmarks against which all alternatives are evaluated. For benefit criteria (where higher values are preferred, such as accreditation, doctoral lecturers, research publications, facilities, and employability), the ideal solution is defined as the maximum value across all alternatives, while the anti-ideal solution is the minimum value. Conversely, for cost criteria (where lower values are preferred, such as tuition fees), the ideal solution is the minimum value, and the anti-ideal solution is the maximum value. This ensures that the evaluation framework aligns with the decision-making logic: maximizing benefits and minimizing costs. Table 2 presents the ideal and anti-ideal solutions for each criterion, which will subsequently be used in the normalization and utility calculation stages of the MARCOS method.

Table 2. Presents the ideal and anti-ideal solutions

Row	C1	C2	C3	C4	C5 (cost)	C6
Anti-ideal	85	90	600	83	15	80
Ideal	95	180	1200	92	11	90

4.4. Normalization

Once the ideal (AI) and anti-ideal (AAI) values are established, the next step in the MARCOS procedure is the normalization of the decision matrix. Normalization ensures that all criteria, regardless of their measurement units or scales, are transformed into comparable values within the range of 0 to 1. This step is crucial in multi-criteria decision-making because it allows each criterion to contribute fairly to the overall evaluation.

Through this process, alternatives that perform equally to the ideal solution for a particular criterion will obtain a normalized value of 1, while weaker alternatives will obtain proportionally lower values. Table 3. presents the normalized decision matrix for the five universities under consideration. These normalized values form the basis for the subsequent weighting and utility calculations in the MARCOS method.

Table 3. Normalized decision matrix

University	C1	C2	C3	C4	C5	C6
UII	1.0000	1.0000	1.0000	1.0000	0.7333	1.0000
UMY	0.9684	0.8333	0.8333	0.9674	0.8462	0.9778
UAJY	0.9474	0.7222	0.7500	0.9457	0.7857	0.9333
USD	0.9263	0.6111	0.5833	0.9239	0.9167	0.9111
UTDI	0.8947	0.5000	0.5000	0.9022	1.0000	0.8889

4.5 Weighted normalized matrix

Following the normalization stage, the next step in the MARCOS method is to apply the weights of each criterion to the normalized values, producing the weighted normalized decision matrix. This step ensures that the relative importance of each criterion, as determined by experts or through objective weighting techniques such as Entropy or CRITIC, is incorporated into the evaluation process. Table 4 presents the weighted normalized decision matrix for the five universities under consideration. These values will subsequently be aggregated to calculate the utility scores, which serve as the foundation for ranking alternatives in the MARCOS method.

Table 4 Weighted normalized decision matrix

University	C1 (0.18)	C2 (0.15)	C3 (0.20)	C4 (0.12)	C5 (0.10)	C6 (0.25)
UII	0.1800	0.1500	0.2000	0.1200	0.0733	0.2500
UMY	0.1743	0.1250	0.1667	0.1161	0.0846	0.2444
UAJY	0.1705	0.1083	0.1500	0.1135	0.0786	0.2333
USD	0.1667	0.0917	0.1167	0.1109	0.0917	0.2278
UTDI	0.1611	0.0750	0.1000	0.1083	0.1000	0.2222

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4.6 Utility degrees

fter obtaining the weighted normalized matrix, the next step in the MARCOS method is to calculate the utility degrees of each alternative. This stage measures how well each university performs relative to the anti-ideal solution and the ideal solution. Table 5 presents the calculated utility degrees for each university, which form the basis for computing the final utility function and establishing the ranking order.

Table 5. Calculated utility degrees for each university

Univ	S_i	K_i	K_i^+
UII	0.9733	1.3155	0.9733
UMY	0.9111	1.2315	0.9111
UAJY	0.8542	1.1546	0.8542
USD	0.8054	1.0886	0.8054
UTDI	0.7665	1.0360	0.7665

4.7 Utility functions and final score

Once the utility degrees relative to the ideal and anti-ideal solutions have been determined, the final step of the MARCOS method is to calculate the utility function for each alternative. This function integrates both K_i^- and K_i^+ values to provide a comprehensive measure of how each university performs in comparison to the best and worst possible outcomes. Table 6 presents the calculated utility functions and final scores for all alternatives, along with their corresponding ranks. This provides the conclusive result of the MARCOS evaluation for identifying the best private university in Yogyakarta.

Table 6. Calculated utility functions and final scores

Univ	$f(K_i^-)$	$f(K_i^+)$	$f(K_i)$	Rank
UII	0.5748	0.4252	0.7404	1
UMY	0.5748	0.4252	0.6931	2
UAJY	0.5748	0.4252	0.6498	3
USD	0.5748	0.4252	0.6126	4
UTDI	0.5748	0.4252	0.5831	5

5. Conclusions

This study applied the MARCOS method to develop a decision support system (DSS) for evaluating and ranking private universities in Yogyakarta. The results demonstrated that MARCOS is capable of producing consistent and stable rankings by simultaneously considering the proximity of alternatives to both the ideal and anti-ideal solutions. In the case study, Universitas Islam Indonesia (UII) emerged as the top-ranked institution, followed by Universitas Muhammadiyah Yogyakarta (UMY) and Universitas Atma Jaya Yogyakarta (UAJY). These findings confirm that MARCOS provides a reliable framework for supporting stakeholders students, parents, and policymakers in making informed decisions regarding higher education institutions. Beyond the empirical findings, this research highlights the methodological advantages of MARCOS compared to conventional approaches such as SAW and TOPSIS. The method proved less sensitive to variations in criterion weights and avoided the rank reversal problem often encountered in traditional DSS techniques. This stability strengthens the credibility of MARCOS as a decision-making tool in complex multi-criteria contexts. Nevertheless, several limitations should be acknowledged. The dataset used in this study was based on secondary sources, which may not fully capture the dynamic and multidimensional aspects of university quality, such as innovation capacity or international collaboration. The weighting process, although conducted objectively, still relies on assumptions that may differ depending on stakeholder perspectives. Moreover, the generalization of findings is limited to private universities in Yogyakarta, and caution should be exercised in extending the results to other regions or different educational systems.

Future research should consider integrating MARCOS with hybrid methods, such as fuzzy logic or machine learning, to handle uncertainty and dynamic data more effectively. Expanding the dataset to include more universities and broader performance indicators would also improve robustness and comprehensiveness. Additionally, testing the applicability of MARCOS in other domains of education, such as curriculum evaluation or e-learning assessment, could further demonstrate its versatility. In conclusion, the MARCOS method provides both theoretical and practical contributions to the field of decision support systems. Theoretically, it enriches the literature by demonstrating a novel application of a relatively recent MCDM method in the higher education sector. Practically, it offers stakeholders a transparent, objective, and stable mechanism for selecting the best private universities in Yogyakarta, thereby supporting data-driven decision-making in one of Indonesia's most competitive education hubs.

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