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A PROMETHEE-GAIA Method-Based Appraisal of Higher Vocational College in Indonesia

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ABSTRACT
Universities have been rated by the Ministry of Research, Technology, and Higher Education since 2015. The goal is to create a database of Indonesian colleges and institutions. Non-vocational/academic colleges and vocational colleges are grouped under the term "college clustering." Vocational schools will be grouped according to four critical criteria as part of this research. For multi-criteria decisions, the PROMETHEE model was employed, and GAIA was used as a geometric analysis in the form of a decision-making visualization, respectively. Alternative two was the most convincing, with a phi value of 0.5125, followed by Alternatives 3 and 1. A clustering indicator for Indonesian colleges found that the second college at the five institutions studied had the best performance in terms of the four weights.

Keywords: *PROMETHEE, GAIA, Multi-Criteria Decision Making, College Clustering*

1. INTRODUCTION

Based on academic criteria, a college ranking is a list or sequence. For the public, this rating provides a wide range of information on college performance that is both accurate and relevant[1]. Although Kemenristekdikti is a government agency in Indonesia that aims to promote the quality of higher education, its base is the accomplishment of university performance for quality improvement, which it sees as a starting point for developing policies tailored to each college cluster[2]

Kemenristekdikti has been conducting this ranking since 2015. The goal is to map or build universities in Indonesia, enhance the quality of higher education by adopting *Tri Dharma Perguruan Tinggi*, the foundation in coaching, the ministry's policy foundation, and give information to the public about university performance[3][4].

Since 2020, this ranking has been called the clusterization of institutions based on the development level. The primary goal is to inform the public about the quality of higher education performance in Indonesia. The Ministry of Research and Higher Education (Kemenristekdikti) separates this clustering into two categories: non-vocational universities/academic education (such as Universities, Institutes, and Higher Schools) and vocational colleges (such as Polytechnics and Academies)[5].

In college rankings, a variety of approaches have been employed. The chart-based ranking aggregation has been used with complete results providing reliable and efficient references by defining a college competition graph with each node representing the university and each directional edge representing the outranking relationship between the two universities[6].

Another way to use the CRITIC approach with a rating mechanism is to normalize data from numerous variables with different units and dimensions, then find the weight of each variable. The domain keyword usage rate variable is an essential variable, according to the weight processing results[7].

The Indonesian government, through Kemenristekdikti, has devised a clustering indicator for college rankings based on 40% input performance

and 60% external performance for both non-vocational and vocational universities as seen in Table 1[5].

Table 1. Weight of Higher Education Clustering Indicators in 2020[5]

Input (20%)		Process (25%)		Output 25%		Outcome (30%)	
Doctoral qualified lecturer	35%	Accreditation of Institutions by BAN-PT	25%	Number of scientific articles indexed per lecturer	30%	Innovation Performance	25%
Lecturers with qualifications of Head Teacher and Professor	30%	Accreditation of study programs by BAN-PT	40%	Research performance	40%	Devotional performance community	25%
Ratio of number of students to lecturers	25%	Online Learning	10%	Student performance	20%	Number of citations per lecturer	20%
Number of foreign students	8%	Cooperation between universities	9%	Number of study programs that have obtained International Accreditation and Certification	10%	Number of patents per lecturer	15%
Number of lecturers working as a practitioner in the industry min 6 months	2%	Completeness of Report PDDIKTI	10%			Percent of graduates Getting a job Within 6 months	15%
		Number of PRODI in collaboration with DUDI, NGO, or QS Top 100 WCU	2%				
		Number of PRODI implementing the *Merdeka Belajar* program	2%				
		Number of students follow the activities *Merdeka Belajar*					

The weight of the ranking criterion in 2020 is shown in Table 1. There are four indicators: a 20% input indicator, a 25% process indicator, a 25% output indicator, and a 30% outcome indicator, with each indicator subdivided into numerous more criteria.

PROMETHEE was used as a decision model in Multi-Criteria Decision Making (MCDM), while GAIA was used as a geometric analysis in the form of visualization in the study[8][9][10][11][12].

Decision-makers are given priority in deciding the order of priorities in multi-criteria analysis. The analysis of the data collected in this study is expected to result in the development of a decision model for ranking vocational institutions in combination with an interactive aid GAIA (Geometric Analysis for Interactive Aid)[13].

2. METHODOLOGY

PROMETHEE is an MCDM approach that was developed for the first time in 1982 by J.P. Brans. This approach is divided into three sections: PROMETHEE I (partial rating), PROMETHEE II (complete ranking), and PROMETHEE III (interval ranking)[14].

The PROMETHEE method is used in this study to rank universities based on the principle of decision support. The sample data were obtained from the Indonesian database Pendidikan Tinggi (PDDikti).

In the overview, the stages for calculating the PROMETHEE technique are as follows[15]: identifying several alternatives, identifying several criteria, defining the kind of preference for each of the most suitable criteria based on data, identifying the best alternative data, and visualization using GAIA.

2.1 Multi-Criteria Decision Making (MCDM)

When decision-makers have a considerable amount of data, the ranking approach in MCDM is used to rate multiple choices. Rankings with many alternatives are handled by comparing a large number of alternatives while taking specific features into account. In management science, this ranking approach is frequently utilized in the selection of strategies, programs, and initiatives[16][17][18]. Figure 1 shows a flowchart of problem solving on multiple decision criteria[15].

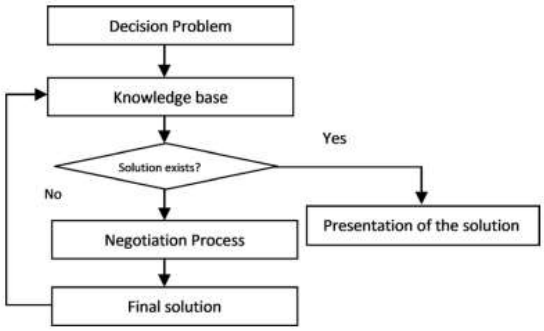

Figure 1. Flowchart of multicriteria decision[15]

2.2 PROMETHEE II

The classic PROMETHEE method was the most often used MCDM technique. PROMETHEE II is the most advanced and widely used technique for outranking. This technique is well-known for its simplicity, yet it is useful when dealing with difficulties involving several criteria. The outranking approach seeks to establish preference relationships, also known as outranking relationships, through a series of alternative paired comparisons based on criteria[19][20].

PROMETHEE II is the simplest and most efficient method for navigating various quantitative and qualitative scales and categorizing alternatives based on their net outranking flow values. The decision-maker evaluates information within each criterion during this procedure[14].

The PROMETHEE II approach distinguishes six preference functions for comparing alternatives based on cost and benefit criteria. The inclusion of many preference functions in PROMETHEE II [13][14]. The following table shows the completion of the PROMETHEE II procedure:

Table 2. Completion in using PROMETHEE II method[21]

Number	Information	Formula
1	Creating a Matrix Decision	Create a matrix that has a basic value as a material to be counted
2	Creating a Normalization Matrix	$r_{ij}=\frac{[x_{ij}-min(x_{ij})]}{max(x_{ij})-min(x_{ij})}$ *for benefit* $r_{ij}=\frac{[max(x_{ij})-x_{ij}]}{max(x_{ij})-min(x_{ij})}$ *for cost*
3	Preference Function $P_{j(i,i)}$	$P_{j(i,i')}=(r_{ij}\le r_{i'j})\ if\ r_{i'j}$ *and* $P_{j(i,i')}=(r_{ij}\le r_{i;j})\ if\ r_{ij}\le r_{i'j}$
4	WP Value (Weak Preference)	$WP(i,i)=\left[\sum_{j=1}^{n}W_j x P_j(i,i)\right]\sum_{j=1}^{n}W_j$
5	$SP_{j(i,i)}$ Value	$SP(i,i)=[max(0,d_j-L_j)]/[dm_j-L_j]$
6	SP Value (Strict Preference)	$SP(i,i')=\left[\sum_{j=1}^{n}W_j X SP_j(i,i)\right]\sum_{j=1}^{n}W_j$
7	Total Preference Value	$TP(i,i')=Min[1,WP(i,i')+(SP(i,i'))]$
8	Entering Flow and Leaving Flow	$\varphi+(i)=\frac{1}{m-1}\sum_{j=1}^{1}TP(i,i')\ (i\#i')$ $\varphi^{-}(i)=\frac{1}{m-1}\sum_{j=1}^{1}TP(i,i')\ (i\#i')$
9	Net Flow Value	$\varphi(i)=\varphi^{+}(i)-\varphi^{-}(i)$

2.3 GAIA (Geometrical Analysis for Interactive Aid) Method

The goal of GAIA's method is to depict the information contained in the matrix graphically. This method analyses critical components to identify fields that allow us to view data in only two dimensions. The GAIA approach enables us to make alternative

comparisons on GAIA fields with remarkably similar lines in the covariance matrix variance. Because all the information required is focused on the GAIA field, we may readily locate alternative couples with similar or opposite performances[22].

As a final point, the capacity to analyze possibilities based on their position is the most significant advantage. By doing so, we can create new categories and gain a deeper comprehension of the data.

Thus, a figure like the one shown in Figure 2 is formed. Since the choice stick points in the direction of alternatives 3 and 4, it appears that these solutions are acceptable. Alternate choices A1 and A5 are considered undesirable since they travel in the opposite direction[11][23].

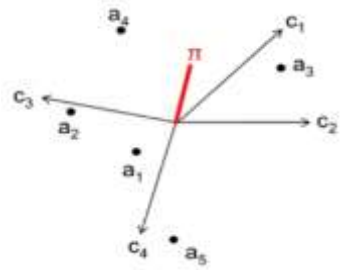

Figure 2. GAIA plane[11]

3. RESULT AND DISCUSSION

Analytic evidence and preset criteria are utilized in the PROMETHEE approach to evaluate college performance.

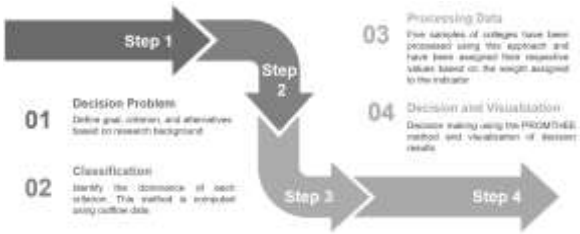

Figure 3. Research Stages

In the initial step, as shown in the stages in Figure 3, we will need to select the best options and specifications. Five vocational schools are used as examples in this study

Table 3. Alternative

Alternatives	Code
Alternatives 1	PT 1
Alternatives 2	PT 2
Alternatives 3	PT 3
Alternatives 4	PT 4
Alternatives 5	PT 5

The criteria are determined in Table 3 based on the Kemenristekdikti indicator of college clustering in 2020.

Table 4. Criteria

Criteria	Code	Information
Criteria 1	C 1	Input
Criteria 2	C 2	Process
Criteria 3	C 3	Output
Criteria 4	C 4	Outcome

After establishing alternatives and criteria, the next stage in classification is to identify the dominance of each criterion. This method is computed using outflow data to obtain more favourable alternative ratings. At this level, data are processed using the Visual PROMETHEE multicriteria decision aid (MCDA) software.

Five samples of colleges have been processed using this approach and have been assigned their respective values based on the weight assigned to the indicator.

Table 5. Alternatives Data

Weight	Criterion	Rule	Alternatives %				
			PT 1	PT 2	PT 3	PT 4	PT 5
20	C1	Max	15	18	20	10	15
25	C2	Max	20	20	18	12	22
25	C3	Max	25	22	20	20	20
30	C4	Max	2	25	25	20	20

Alternative two or PT 2 has the highest rating based on the performance of each indicator weight provided during clustering since it contains the most significant phi, phi+, and phi- values. The complete ranking of the five options is shown in Table 6. Figure 4 shows the GAIA PROMETHEE

visualization, with alternative two (PT 2) ranking top in estimating vocational college achievement.

Table 6. PROMETHEE Flow Table

Rank	Alternative	Phi	Phi+	Phi-
1	Alternative 2	0,5125	0,6875	0,1750
2	Alternative 3	0,1750	0,4875	0,3125
3	Alternative 1	0,1125	0,4250	0,3125
4	Alternative 5	-0,0750	0,3000	0,3750
5	Alternative 4	-0,7250	0,000	0,7250

Based on process indicators, outputs, and inputs, Alternative 2 is the best alternative. The rankings' findings are represented so that decision-makers in judging college achievement can be fully informed.

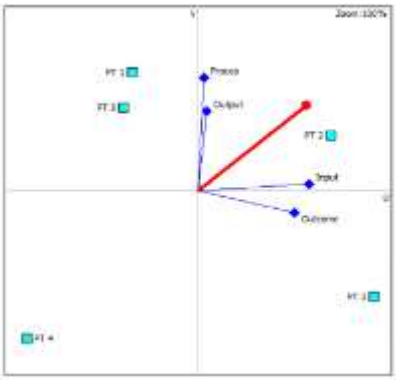

Figure 4. PROMETHEE GAIA for Ranking of Higher Vocational Colleges

4. CONCLUSION

Based on preset criteria, the PROMETHEE decision support system assists decision-makers in evaluating the performance of colleges. PROMETHEE and GAIA techniques were combined in research using four criteria. Alternative 2 with a convincing value of 0.5125 is the result of this investigation, followed by alternatives 3 and 1. College 2 (alternative 2) is the top university in Indonesia based on the four weighting parameters of the clustering of Indonesian institutions.

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