# Design of Decision Support System for Selection of Outstanding Students Using AHP and Promethee Methods

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**ABSTRACT**

Student affairs often has difficulty in determining students that are sent to events because of many outstanding students at the institution. So far, the sending of students is still intuitive and subjective. Therefore, this research aims to design and build a decision support system that can provide advice to determine the best student that will be sent to the event. In this research, the method of decision support system that is used is a combination of AHP and Promethee. In implementation, AHP is executed to get criteria weight. After that, Promethee is executed to determine the order of candidates priority. The purpose of combination is to increase the quality of advice about the selection of students. The result of research shows that with the decision support system that is built, student affairs can choose the students that are sent to events more quickly, accurately, and objectively. Gist-The student affairs department often has difficulty in determining outstanding students who will be sent to events due to the large number of outstanding students in the institution. Due to the absence of a decision support system, sending students so far is still intuitive and subjective. Therefore, this research aims to design and build a decision support system that can provide advice to determine the best students to be sent to the event. In this case, the decision support system method used is a combination of Analytical Hierarchy Process (AHP) and Promethee. In its application, AHP is run first to get the weight of the criteria. After that, Promethee is run to determine the priority order of prospective event participants. The purpose of this combination is to improve the quality of student selection advice. The results showed that with this decision support system, the student affairs department can select students who are sent to an event more quickly, precisely, and objectively.

**Keyword : Decision Support System, Student Selection, AHP, Promethee.**



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## 1. INTRODUCTION

Student Affairs is one of the Technical Implementation Units (UPT) at STIKOM Surabaya, which is one of its duties. Is to select and send outstanding students to an event based on their talents and interests. Talent and interest are the potential that exists in every individual created by God. Talents and interests that are developed intensively will produce an achievement that can later add value to the individual's soft skills. The National Association of Colleges and Employers (NACE) in 2005 reported that in general, graduate users require job skills in the form of soft skills 82 percent and hard skills 18 percent [1].
In relation to the talents and interests of students, an educational institution will not be separated from organizing events, both events within the institution itself and events from outside the institution. For the purposes of the event, especially the determination of students who will be sent is a difficult job for the student affairs department so far. This is because the institution has many students who excel in a field related to the event.

The process of selecting outstanding students who will be sent to an event will take a long time if it is done through selection. This selection process is not often done. Only very large and special events such as outstanding students (mawapres) from the Coordinator of Private Universities (Kopertis), the student selection process is carried out. The selection assessment process so far is still manual so that the student affairs department must provide a considerable amount of time allocation, especially for selections that are attended by many students as prospective participants.

For the selection of outstanding students, the student affairs department should not do it carelessly because it will create injustice for students who are more accomplished in that field. In addition, this will harm the institution itself because sending less potential participants will reduce the opportunity to make achievements. However, the reality is that the determination of outstanding students who will be sent to an event by the student affairs section of STIKOM Surabaya is still a lot intuitive and subjective so that the possibility of sending event participants is quite large. In the case of selecting outstanding students, the solution that can be offered is the use of Multi Criteria Decision Making (MCDM). MCDM is a decision-making technique from several existing alternatives based on certain criteria [4]. Some examples of methods that.

MCDM includes Analytical Hierarchy Process (AHP), Preference Ranking Organization Method for Enrichment Evaluation (Promethee), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination Et Choix Traduisant la Realite (Electre), and others. For the selection of outstanding students, the method used is a combination of AHP and Promethee. The selection of these methods is based on consideration of the advantages possessed by each method. Based on the above problems, the student affairs section of STIKOM Surabaya needs a decision support system application that is able to provide the best alternatives or suggestions in determining outstanding students who will be sent to an event. So, the student affairs department can further improve the quality of sending students who represent the
institution in an event.

Thus, the objectives of this study are as follows:

1. Designing and building a decision support system for selecting outstanding students based on talent interests at STIKOM Surabaya using a combination of AHP and Promethee methods.
2. Implement a decision support system for selecting outstanding students quickly and precisely.
3. Proving that the combination of AHP and Promethee is better in determining outstanding students to an event than the AHP or Promethee method alone.

## 2. RESEARCH METHOD/MATERIAL AND METHOD/LETERATURE REVIEW

### A. Literature Review

The closest previous research to this research is research conducted by Handayani and Wakhidah and research conducted by Mursanto and Sari. In Handayani and Wakidah's research, researchers only used the AHP method in selecting outstanding students at the University of Semarang. This research was conducted to facilitate the selection team in deciding which students are entitled to get the title of outstanding through a multicriteria weighting process. This research uses Visual Basic 6.0 as a programming language and Microsoft Access as a data storage medium [2].

In Mursanto and Sari's research, researchers have used AHP and Promethee in order to rank object-oriented software. They also used MOOD2 which consists of 11 subcriteria to measure the 4 most important things (criteria) of object- oriented design, namely: encapsulation (4 subcriteria), inheritance (3 subcriteria), polymorphism (2 subcriteria), and coupling (2 subcriteria). In this case, AHP serves to determine the weights of MOOD2 criteria and Promethee serves to determine the final ranking of software quality. The ranking of the quality of object-oriented code implementation is very useful for evaluating and selecting the best object-oriented software design [3].

In Mursanto and Sari's research, AHP was combined with Promethee with the aim of obtaining better and objective recommendation results. The combination of these two methods utilizes the advantages of each method. AHP has advantages in determining the weight and hierarchy of criteria, while Promethee has advantages in the process of ranking alternatives using different preference functions and weights. In other words, because Promethee lacks support for determining the weights and hierarchy of criteria and does not have consistency guarantees/protections when determining weights like AHP. Meanwhile, AHP is also not as good as Promethee in calculation and ranking. Therefore, AHP is combined with Promethee. The combination of AHP and Promethee is also recognized to produce more stable rankings and less subjectivity. The weakness of Mursanto and Sari's (2011) research is that the number of criteria and sub-criteria is predetermined so it is not dynamic. In addition, the research cannot distinguish the order of better alternatives if there are several alternatives that have the same final value.

The difference between this research and previous research is that this research has a number of criteria and sub-criteria that are not predetermined so that it is more flexible and dynamic according

to needs. In addition, this web-based application will re-rank if there are several alternatives that have the same final value. Ranking is still done based on the results of the AHP and Promethee combination. For alternatives that have the same value, they will be compared again based on the value at the first, second, and so on until a difference in value is found at a weight. If there is still no difference in value, then the final result remains the same according to the previous AHP and Promethee.

**B. Theoretical Foundation**

1. Basic Concepts of Decision Support Systems
   The definition of a system is a set of things or activities or elements or subsystems that work together or that are connected in certain ways so that they form a single unit to carry out a function to achieve a goal [7].
   In general, a decision support system (DSS) is an interactive, computer-based system that helps decision makers utilize data and models to solve unstructured and semi- structured problems [8]. Actually, the initial definition, SPK is a model-based system consisting of procedures in data processing and consideration to assist managers in making decisions. In order to achieve its goals, the system must be simple, easy to control, adaptable, complete on important things, and easy to communicate with.
2. Analytical Hierarchy Process
   The Analytical Hierarchy Process (AHP) method was developed in the early 1970s by Thomas L. Saaty, a mathematician from the University of Pittsburg. The AHP is essentially designed to rationally capture the perceptions of people who are closely related.
   This analysis is aimed at modeling unstructured problems, usually set to solve quantitative problems, problems that require judgment or complex or unstructured situations, in situations where statistical data are not available. This analysis is intended to model unstructured problems, usually set to solve quantifiable problems, problems that require judgment or in complex or unconstrained situations, in situations where statistical data is minimal or non-existent and only qualitative based on perception, experience or intuition.

AHP is also widely used in decisions for many criteria, planning, resource allocation and prioritization of strategies owned by players in conflict situations [5]. So, AHP is an analysis used in decision making with a systems approach, where decision makers try to understand a system condition and help make predictions in making decisions.

The AHP model uses human perception which is considered
"Experts" as the main input. The criteria for experts here does not mean that the person must be a genius, smart, have a doctorate degree and so on but rather refers to a person who really understands the problem, feels the consequences of a problem or has an interest in the problem. Measurement of qualitative matters is very important considering the increasing complexity of problems in the world and the higher level of uncertainty.

As described by Saaty, the AHP method can be used to assist decision-making in the following way:

a. Define decision objectives, criteria, and alternatives
b. Create a "hierarchical tree" for various decision criteria and alternatives.
c. Form a pairwise comparison matrix, for example named matrix A. The number in the i-th row and j-th column (Ai,j) is the relative importance of Ai compared to Aj. For many problems, a scale of 1 to 9 is the best scale for expressing opinions. The values and qualitative opinion definitions of Saaty's comparison scale can be seen in Table 1.

Table 1. Pairwise Comparison Scale

| Intensity of Interest | Description |
|---|---|
| 1 | Both elements are equally important |
| 3 | One element is slightly more importantthan any other element |
| 5 | One element is more important thanOthers. |
| 7 | One element is clearly more absolutelyessential than other elements |
| 9 | One element is absolutely essential thanother elements |
| 2,4,6,8 | Values between two adjacent value considerations |

When an element is compared to itself
If element i (Ai) compared to element j (Aj) gets a certain value, then Aj compared to Ai is the opposite.

d. Create a priority ranking of the pairwise matrix by determining the eigenvector. The method is as follows:
   - Squaring the pairwise comparison matrix
     The general principle of matrix multiplication is the multiplication of the rows of the first matrix by the columns of the second matrix.
   - Summing up each row of the matrix from the squaring method (a), then normalized, the method is to divide the number of rows by the total rows until the eigenvector value is obtained (1).
   - To double-check the eigenvector value, square the matrix from method (a) and do method (b) again, until a new eigenvector is obtained. Then, compare the first and second eigenvectors. If between the two, there is no change in value or only a slight change then the first eigenvector value is correct. However, if otherwise, then the first eigenvector value is still wrong and re-do methods (a) to (c), until the eigenvector value does not change or only changes slightly.

e. Ranking alternatives from the pairwise matrix of each alternative by determining the eigenvector of each alternative. The method used is the same when ranking the priorities above.
   - Determining the pairwise comparisons matrix of each alternative
   - Determine the eigenvector value of each alternative
   - Ranking alternatives
   - The ranking of alternatives can be determined by multiplying the alternative eigenvector value by the criteria eigenvector value.

f. Logical Consistency
   All elements are logically grouped and consistently warned according to a logical criterion. The weight matrix obtained from the pairwise comparison results must have a cardinal and ordinal relationship. The relationship can be shown as follows:
   Cardinal relationship $a_{ij} . a_{jk} = a_{jk}$
   Ordinal relationship $A_i > A_j . A_j > A_{jk}$ then $A_i > A_k$ The above relationship can be seen from the following two points
   - By looking at multiplicative preferences, for example if grapes are four times as good as mangoes and mangoes are twice as good as bananas so grapes are eight times as good as bananas.
   - Looking at transitive preferences, for example, grapes are better than mangoes and mangoes are better than bananas, grapes are better than bananas.

3. Preference Ranking Organization Method for Enrichment Evaluation

Preference Ranking Organization Method for Enrichment Evaluation (Promethee) is one of the ranking determination methods in Multi Criteria Decision Making (MCDM). Promethee is a method of determining the order (priority) in multicriteria analysis [6]. The assumption of criteria dominance used in Promethee is the use of values in the outranking relationship.
In the first phase, the value of the outranking relationship is based on consideration of the dominance of each criterion. The preference index is determined and the outranking values are graphically presented based on

the preferences of the decision maker. The basic data for evaluation with the Promethee method is presented in Table 2.

Table 2. Promethee Base Data

| | f1(.) | f2(.) | ..... | fj(.) | ..... | fk(.) |
|---|---|---|---|---|---|---|
| a1 | f1(a1) | f2(a1) | ..... | fj(a1) | ..... | fk(a1) |
| a2 | f1(a2) | f2(a2) | ..... | fj(a2) | ..... | fk(a2) |
| Ai | f1(ai) | f2(ai) | ..... | fj(ai) | ..... | fk(ai) |
| An | f1(an) | f2(an) | ..... | fj(an) | ..... | fk(an) |

To provide a better description of the area that is not the same, the criterion value difference function between alternatives H (d) is used where this has a direct relationship with the preference function P. In Promethee, six criterion preference functions are presented, namely: ordinary criteria, quasi criteria, criteria with linear preferences, level criteria, criteria with linear preferences and areas that are not different, and Gaussian criteria. In this research, the criterion preference function used is the criterion with linear preferences and non-different areas (criterion type V) with the following equation:

$$H(d) = \begin{cases} 0 \text{ jika } |d| \leq q \\ (|d| - q)/(p - q) \text{ jika } q < |d| \leq p \\ 1 \text{ jika } p < |d| \end{cases} \quad (1)$$

Description:
1. H (d) : Criterion difference function between alternatives
2. d : Difference in Criteria score
3. Parameter (p ): upper trend value.
4. Parameter (q ) : is a fixed value

This research will perform the stages of the System Development Life Cycle (SDLC) with the waterfall model as shown in Fig. 2.

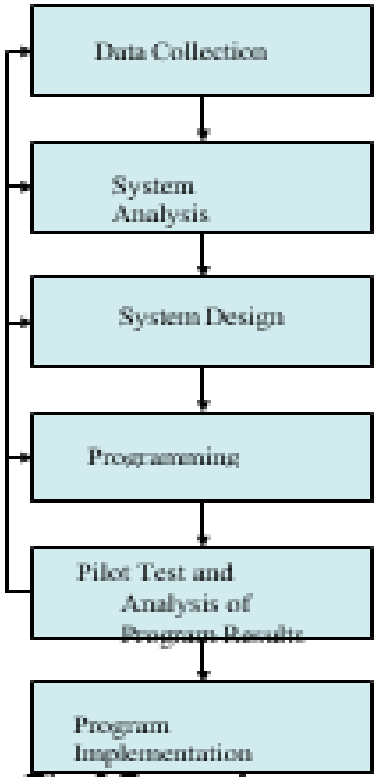


Figure 1. Research Stages

Fig. 1 shows that the research begins with data collection, then system analysis, system design, program creation, testing and analysis of program results, and the last stage is program implementation or deployment. If there are shortcomings in the testing and analysis stage of the program results, then the research can return to the previous stages that need improvement so that the results of the program can be improved.

## 3. RESULTS AND DISCUSSION

After conducting the research stages as previously described, this research finally succeeded in making and implementing a decision support system for selecting outstanding students based on talents and interests. The main steps in the process of selecting outstanding students are as follows:
First, the student affairs officer must fill in the event data first. Filling in the event data can be seen in Fig. 2.

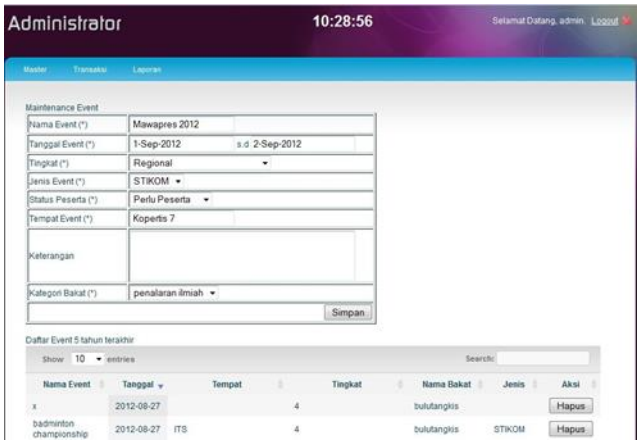


Figure 2. Filling in Event Data

Second, student affairs officers must fill in the criteria and subcriteria data used in the selection process. Filling in the criteria and sub-criteria data can be seen in Fig. 3 and Fig. 4.

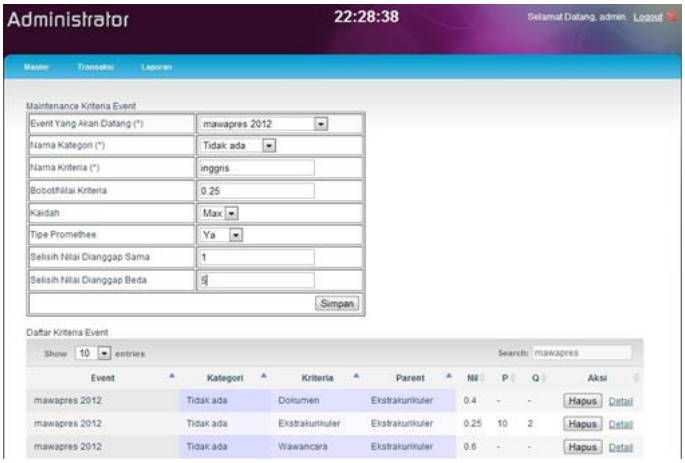


Figure 3. Filling in Criteria Data


Figure 4. Filling in Sub-Criteria Data

Third, the student affairs officer must determine the jury and the jury's access rights to the criteria assessment.The process of determining the jury can be seen in Fig. 5

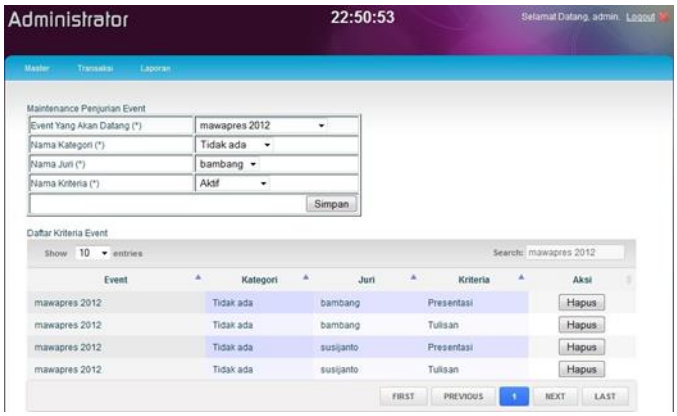


Figure 5. Jury Determination

Fourth, student affairs officers must determine the prospective event participants to be selected. The process of determining prospective event participants can be seen in Fig. 6

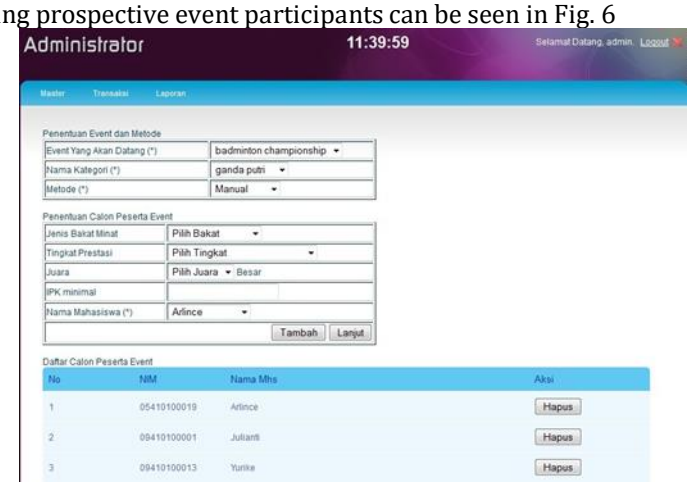


Figure. 6 Determination of potential event participants

Fifth, student affairs officers or appointed judges must fill in the assessment of prospective event participants on each criterion. If using the AHP or combination method, student officers or judges must fill in the assessment between criteria first. The process of assessing criteria and prospective event participants can be seen in Figs. 7 and 8.

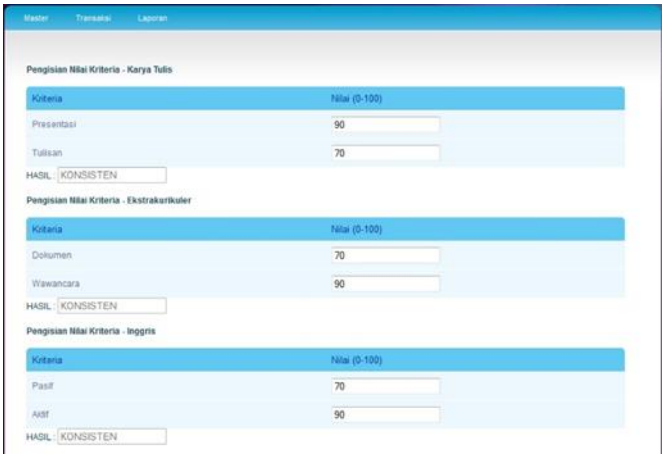


Figure 7. Criteria assessment

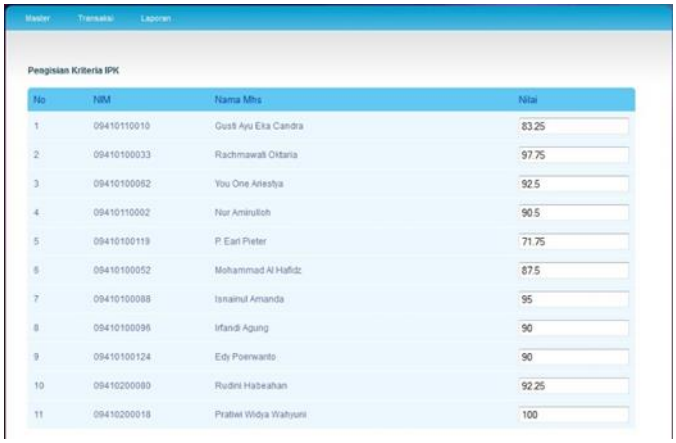


Figure 8. Assessment of potential event participants

Based on the test results, the rankings produced by manual calculation, AHP, Promethee, and the combination of AHP and Promethee are very likely to be correct.

Different. In the trial data, there were 11 participants who participated in the selection of the 2012 outstanding student event (mawapres). In this selection, the jury used 4 criteria, namely: GPA (20%), Scientific Work (30%), Extracurricular Activities (25%), and English (25%). Each of these criteria has sub-criteria. For more details, the list of criteria for this trial can be seen in Fig. 9.


Figure 9. List of Criteria

After the criteria and sub-criteria are determined, the next stage is the assessment of the selection participants on each criterion/sub-criteria. Assessment data for GPA, extracurricular activities, and English criteria can be seen in Table 3. Assessment data for scientific work criteria can be seen in Table 3.

Table 3. Assessment Criteria for IPK, Extras, And English

| No. | Name | GPA | GPA Score | Extracurricular | | English | |
|---|---|---|---|---|---|---|---|
| | | | | Doc | Wcara | Passive | On |
| 1 | Pratiwi | 4 | 100 | 68 | 0.64 | 82 | 56 |
| 2 | Isnainul | 3.8 | 95 | 84.7 | 0.67 | 51 | 50 |
| 3 | You | 3.7 | 92.5 | 73.7 | 0.685 | 87 | 75 |
| 4 | Hafidz | 3.5 | 87.5 | 141 | 0.812 | 85 | 75 |
| 5 | Gusti | 3.33 | 83.25 | 121 | 0.665 | 63 | 45 |
| 6 | Edy | 3.6 | 90 | 68 | 0.695 | 55 | 61 |
| 7 | Rudini | 3.69 | 92.25 | 56 | 0.715 | 42 | 48 |
| 8 | Pietter | 2.87 | 71.75 | 93 | 0.665 | 55 | 38 |
| 9 | Irfandi | 3.6 | 90 | 187.6 | 0.715 | 75 | 43 |
| 10 | Nur | 3.62 | 90.5 | 77 | 0.689 | 78 | 60 |
| 11 | Rachma | 3.91 | 97.75 | 22 | 0.628 | 82 | 51 |

Table 4. Assessment of Scientific Work Criteria

| No. | Name | Jury 1 | | Jury 2 | |
|---|---|---|---|---|---|
| | | Article | Presentation | Article | Presentation |
| 1 | Pratiwi | 63.4 | 86 | 56 | 70 |
| 2 | Isnainul | 53.8 | 79 | 56.2 | 77 |
| 3 | You | 59 | 87 | 59.8 | 95 |
| 4 | Hafidz | 66.6 | 99 | 60.4 | 90 |
| 5 | Gusti | 42.2 | 86 | 43 | 87 |
| 6 | Edy | 56.6 | 84 | 56 | 82 |
| 7 | Rudini | 40.2 | 85 | 58.6 | 89 |
| 8 | Pietter | 50 | 85 | 51 | 78 |
| 9 | Irfandi | 61.2 | 86 | 58 | 86 |
| 10 | Nur | 62.2 | 90 | 58 | 90 |
| 11 | Rachma | 47 | 77 | 54.8 | 77 |

With the same participant score input for each method, It turns out that the application displays different ranking results for each method. For more details, the ranking results from manual calculation, AHP, Promethee, and the combination of AHP and Promethee can be seen in Table 5.

Table 5. Comparison of Ranking Results

| No. | Manual | AHP | *Promethee* | Combination |
|---|---|---|---|---|
| 1 | Hafidz | Hafidz | Hafidz | Hafidz |
| 2 | Irfandi | You | You | You |
| 3 | You | Irfandi | Irfandi | Nur |
| 4 | Nur | Nur | Nur | Irfandi |
| 5 | Pratiwi | Pratiwi | Pratiwi | Edy |
| 6 | Gusti | Edy | Edy | Pratiwi |
| 7 | Edy | Gusti | Isnainul | Isnainul |
| 8 | Isnainul | Rachma | Rachma | Rudini |
| 9 | Rachma | Rudini | Gusti | Gusti |
| 10 | Rudini | Isnainul | Rudini | Rachma |
| 11 | Pietter | Pietter | Pietter | Pietter |

There is nothing wrong with the four different ranking results. However, the ranking produced by the combination of AHP and Promethee has a good ranking quality. This is because the advantages of the AHP and Promethee methods are combined to obtain alternative rankings. AHP is good in terms of

weighting criteria because it can guarantee consistency used for weighting, while Promethee which has the advantage of ranking is used to rank alternatives.

From the test results, AHP is indeed proven to be very good in terms of determining the weight of the criteria because it can guarantee consistency in the level of importance of the weight itself. This is not the case with Promethee. Consistency checking by the AHP method is an advantage in terms of criteria weighting. However, AHP is not necessary if the event organizer has already determined the criteria weights. For this case, Promethee can be directly used to perform the ranking. On the other hand, if there are no criteria weights, it is better to do the AHP method first so that the criteria weights are consistent with the level of importance.

AHP needs to be combined with Promethee in order to obtain better ranking results. If AHP stands alone, the ranking is only obtained from the multiplication between the eigenvector of alternatives on each criterion and the eigenvector of criteria weights. In AHP ranking, there is no adjustment like Promethee. In the Promethee method, decision makers can determine the difference in values where alternatives are considered to lose absolutely, win absolutely, or win partially. So in Promethee, especially type V, the winning alternative is not always given a value of 1, but the value can range from 0 to 1.

The advantage obtained with the adjustment is that if there are criteria that have the same weight and the scores between participants have the same value difference by winning alternately in each method, then the best participant can still be determined as long as the value difference in each criterion is different. For example, participant 1 scores 88 and participant 2 scores 80 on criterion A, which has a weight of 50%. Meanwhile, in criterion B, which is also 50% weighted, participant 1 scores 80, while participant 2 scores 88. If done with ordinary calculations, the scores of the two participants are the same. In other words, there is no superior participant.

With different adjustments for each criterion in the Promethee method, the best participant can still be determined. For example, criterion A has a lower score limit of 5 and an upper score limit of 10, while criterion B has a lower score limit of 5 and an upper score limit of 20. If participant 1 with a score of 88 is compared to participant 2 with a score of 80 on criterion A, then participant 1 gets a score of 0.6 (<88-80>- 5/<10-5>) and participant 2 gets a score of 0. Meanwhile, if participant 2 with a score of 88 is compared to participant 1 with a score of 80 on criterion B, then participant 2 gets a score of 0.2 (<88-80>-5/<20-5>) and participant 1 gets a score of 0. Thus, participant 1 still has a greater score than participant 2.

In short, the advantage of the AHP method alone lies in the weighting of criteria due to consistency checking, while the disadvantage is that the ranking algorithm is not good enough. In contrast, the Promethee method has an advantage in the ranking algorithm due to the adjustment, but has a disadvantage in the weighting of criteria due to the absence of consistency checking. So, the combination of AHP and Promethee method is a good solution to produce a better ranking. In the criteria weighting process using AHP, while the ranking algorithm uses the Promethee method. The weakness in the combination of AHP and Promethee methods is that it takes longer than the AHP or Promethee method alone.

## 4. CONCLUSION

After conducting the SDLC stage, this research succeeded in making a decision support system for selecting outstanding students. After testing the system that has been made, the following conclusions can be drawn:

1. The system created can speed up the student selection process because the assessment process has been computerized. In the selection process, student affairs does not need to re-enter the scores from the jury. The jury can directly enter the value through the application.
2. The system created can produce more precise and objective student selection decisions because the selection process is carried out using scientific methods.
3. The ranking results from the combination of AHP and Promethee proved to be better than the ranking results from the AHP or Promethee method alone. This is because the advantages of each method are used.

**REFERENCES**


[1] Sari, I.P., Mawengkang, H., & Efendi, S (2019). Fuzzy Analytical Hierarchy Process (FAHP) Ekspansi Untuk Inovasi Kerangka Pengukuran Kinerja. InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan, 3(2), 228-233.

[2] Batubara, I.H., & Sari, I.P (2021). Combination of Analytic Hierarchy Process (AHP) Method and Profile Matching Method with Matrix Decomposition in Determining Olympiad Candidates. International Journal of Economic, Technology and Social Sciences, 2, 470-477

[3] Sari, I.P (2019). Analytical Hierarchy Proses (AHP) Ekspansi untuk Pengambilan Keputusan Masalah dalam Inovasi Kerangka Pengukuran Kinerja. Universitas Sumatera Utara.

[4] Sari, I.P., Hutagalung, F.S., & Hutasuhut, B.K (2020). Determination of Campus Promotion Policy Strategy Applied The Profile Matching Method. Journal of Computer Science, Information Technology and Telecommunication Engineering 1 (1), 17-23.

[5] Ramadhani, F., Al-Khowarizmi, A., & Sari, I.P (2021). Implementasi Metode Topsis Dalam Menangani Masalah Pengalokasian Dosen Pembimbing Skripsi Dilingkungan Fakultas Ilmu Komputer Dan Teknologi Informasi Universitas Muhammadiyah Sumatera Utara. InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan 6 (1), 104-110.

[6] Sari, I.P., Al-Khowarizmi, A.K., Ramadhani, F., & Sulaiman, O.K. (2023). Implementation of the Selection Sort Algorithm to Sort Data in PHP Programming Language. Journal of Computer Science, Information Technology and Telecommunication Engineering, 4(1).

[7] Hutasuhut, B.K., Batubara, I.H., Sari, I.P (2021). Analisa Sistem Pendukung Keputusan Penentuan Kosentrasi Matakuliah Pilihan menggunakan Metode Topsis. InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan 6(1), 11-114.

[8] Sari, I.P., Batubara, I.H., & Al-Khowarizmi, A (2021). Sensitivity Of Obtaining Errors In The Combination Of Fuzzy And Neural Networks For Conducting Student Assessment On E-Learning. International Journal of Economic, Technology and Social Sciences (Injects), 2(1), 331-338.

[9] Sari, I.P., Fahroza, M.F., Mufit, M.I., & Qathrunad, I.F (2021). Implementation of Dijkstra's Algorithm to Determine the Shortest Route in a City. Journal of Computer Science, Information Technology and Telecommunication Engineering, 2(1), 134-138.

[10] Batubara, I.H., Saragih, S., Syahputra, E., Armanto, D., Sari, I.P., Lubis,B.S., & Siregar, E.F.S (2022). Mapping Research Developments on Mathematics Communication: Bibliometric Study by VosViewer. AL-ISHLAH: Jurnal Pendidikan 14(3), 2637-2648.

[11] Sari, I.P., Al-Khowarizmi, A.K., & Batubara, I.H. (2021). Analisa Sistem Kendali Pemanfaatan Raspberry Pi sebagai Server Web untuk Pengontrol Arus Listrik Jarak Jauh. InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan, 6 (1), 99-103.

[12] Hariani.,P.P, Sari.,I.P, & Batubara., I.H. (2021). Implementasi e-Financial Report BUMDes. IHSAN: JURNAL PENGABDIAN MASYARAKAT, 3 (2), 169-177.

[13] Sari, I.P., Basri, Mhd., Ramadhani, F., & Manurung, A.A. (2023). Penerapan Palang Pintu Otomatis Jarak Jauh Berbasis RFID di Perumahan. Blend Sains Jurnal Teknik, 2(1), 16-25.

[14] Batubara, I.H., & Sari, I.P. (2021). Penggunaan software geogebra untuk meningkatkan kemampuan pemecahan masalah matematis mahasiswa. Scenario (Seminar of Social Sciences Engineering and Humaniora), 398-406

[15] Sari, I.P., & Batubara, I.H. (2020). Aplikasi Berbasis Teknologi Raspberry Pi Dalam Manajemen Kehadiran Siswa Berbasis Pengenalan Wajah. JMP-DMT 1(4), 6.

[16] Batubara, I.H., Sari,I.P., Hariani, P.P., Saragih, M., Novita, A., Lubis, B.S., & Siregar, E.F.S. (2021). Pelatihan Software Geogebra untuk Meningkatkan Kualitas Pembelajaran Matematika SMP Free Methodist 2. Martabe: Jurnal Pengabdian Kepada Masyarakat, 4(3), 854-859.

[17] Sari., I.P, Batubara., I.P, Al-Khowarizmi., A, & PP Hariani. (2022). Perancangan Sistem Informasi Pengelolaan Arsip Digital Berbasis Web untuk Mengatur Sistem Kearsipan di SMK Tri Karya. Wahana Jurnal Pengabdian kepada Masyarakat 1 (1), 18-24.

[18] Batubara., I.H, Sari., I.P, EFS Siregar, & BS Lubis. (2021). Meningkatkan Kemampuan Penalaran Matematika Melalui Metode Penemuan Terpandu Berbantuan Software Autograph. Seminar Nasional Teknologi Edukasi Sosial dan Humaniora 1 (1), 699-705.

[19] Sari., I.P, A Syahputra, N Zaky, RU Sibuea, & Z Zakhir. (2022). Perancangan sistem aplikasi penjualan dan layanan jasa laundry sepatu berbasis website. Blend sains jurnal teknik 1 (1), 31-37.

[20] Sari., I.P, A Azzahrah, FQ Isnaini, L Nurkumala, & A Thamita. (2022). Perancangan sistem absensi pegawai kantoran secara online pada website berbasis HTML dan CSS. Blend sains jurnal teknik 1 (1), 8-15.

[21] Sari.,I.P, & Ramadhani., F. (2021). Pengaruh Teknologi Informasi Terhadap Kewirausahaan Pada Aplikasi Perancangan Jual Beli Jamu Berbasis WEB. Prosiding Seminar Nasional Kewirausahaan 2 (1), 874-878.

[22] Sari., I.P, A Jannah, AM Meuraxa, A Syahfitri, & R Omar. (2022). Perancangan Sistem Informasi Penginputan Database Mahasiswa Berbasis Web. Hello World Jurnal Ilmu Komputer 1 (2), 106-110.

[23] Hutasuhut, B.K., Sari, I.P., & Al-Khowarizmi, A (2023). Analysis the Effect of Digitalization and Technology on Web-Based Entrepreneurship. Journal of Computer Science, Information Technology and Telecommunication Engineering 4(1).
[24] Sari., I.P, & Batubara., I.H. (2021). Perancangan Sistem Informasi Laporan Keuangan Pada Apotek Menggunakan Algoritma K-NN. Seminar Nasional Teknologi Edukasi dan Humaniora (SiNTESa) 1 (2021 - ke 1.
[25] Sari., I.P, & Batubara., I.H. (2021). User Interface Information System for Using Account Services (Joint Account) WEB-Based. International Journal of Economic, Technology and Social Sciences (Injects), 462-469.
[26] PP Hariani, Sari., I.P, & Batubara., I.H. (2021). Android-Based Financial Statement Presentation Model. JURNAL TARBIYAH 28 (2), 1-16.
[27] Sari., I.P, Batubara., I.H, & M Basri. (2022). Implementasi Internet of Things Berbasis Website dalam Pemesanan Jasa Rumah Service Teknisi Komputer dan Jaringan Komputer. Blend Sains Jurnal Teknik 1 (2), 157-163.
[28] Sari., I.P, Al-Khowarizmi., A, & Batubara., I.H. (2021). Implementasi Aplikasi Mobile Learning Sistem Manajemen Soal dan Ujian Berbasis Web Pada Platform Android. IHSAN: JURNAL PENGABDIAN MASYARAKAT 3 (2), 178-183.
[29] Batubara, I.H., Saragih, S., Simamora, E., Napitupulu, E.E., Sari, I.P. (2022). Analysis of Student's Mathematical Communication Skills through Problem Based Learning Models Assisted by Augmented Reality. Budapest International Research and Critics Institute-Journal (BIRCI-Journal), 5(1), 1024-1037.