Portfolio Based Outstanding Students Recommendations Using AHP and TOPSIS

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Abstract. Determining outstanding students is important to determine the development of student quality. In addition, it can be used as a recommendation to participate in the annual national student achievement selection program. A portfolio is a collection of works created to reflect its creator. A student portfolio is a collection of documentation of student work to show their efforts, progress, and achievements in one or more fields. A portfolio can be used as an assessment instrument to determine the development of student quality or performance. Therefore, student performance assessment can be done through portfolio data. Thus, recommendations for selecting outstanding students are made by utilizing the AHP and TOPSIS methods based on student portfolios. The portfolio data used includes competition data, awards, work results, and organizational careers. In implementing the AHP method, a CR value of 0.046348 was obtained, which proves that the weighting level of the predetermined criteria is consistent.

Keywords: student performance, portfolio, recommendation

1 Introduction

The selection of outstanding students is an annual competition held nationally by the National Achievement Center under the auspices of the ministry. The selection is intended to provide appreciation to the best students at the Bachelor and Diploma program levels. This motivates all students to develop their abilities in achieving awards in the competition[1][2].

Trunojoyo University of Madura (UTM) is one of the State Universities in East Java that also has the opportunity to participate in the national level student achievement selection event. Including the study program in it, namely Informatics education. Currently, to prepare for the competition, UTM is conducting a University level selection. Therefore, delegates are needed for each study program to participate in the selection. so that they can become campus representatives at the next level. So far, in the informatics education study program, there has been no automatic selection of outstanding students. The many criteria in considering students who represent in the selection of outstanding students are one of the difficulties in selecting candidates. In this case, representatives of each study program definitely need a system to help determine outstanding students.

From the explanation above, a recommendation system is needed that can provide alternatives for outstanding students. The proposed recommendation system utilizes the Analytical

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Hierarchy Process (AHP) method and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). AHP is a method that performs analysis by giving values to each criterion variable. Then a paired matrix is made from each of these variables. After getting the weighting value from the AHP method, the TOPSIS method is then used in ranking outstanding students by optimizing negative and positive ideal solutions. With several stages of this process, it is intended to get recommendations for outstanding students easily and quickly. This is supported by previous research that has utilized a combination of the AHP and TOPSIS methods for decision support systems in selecting outstanding students. However, the criteria used are different.[3][4][5][6].

In determining the recommendation of outstanding students, portfolios are used as an assessment of student achievement. A portfolio is a collection of works created to describe the creator. Portfolios can be used to determine student achievements. Meanwhile, a student portfolio is a collection of documentation of student work to show their efforts, progress, and achievements in one or more fields[7]. Portfolios are considered as one of the assessment instruments in determining the development of student quality[8]. Several student portfolios can represent the assessments in the selection.

2 Research Method

The research procedure describes in detail the stages taken using the waterfall model. The research procedure framework is explained in Table 1.

Table 1. Research Procedures.

Procedures	Activity
Analysis	Observation and Data Collection
Design	Designing data structure according to needs analysis for model application
Implementation	Methods Implementation
Testing	Making comparison with manual calculations

In this study, the research subjects taken were students of the Informatics Education Study Program, Faculty of Teacher Training and Education, Trunojoyo University, Madura with a total of 256 data and using 5 criteria adjusted to the 2024 PILMAPRES guide for undergraduate programs, which are shown in Table 2.

Table 1. Value of each criteria.

Criteria	Detail Criteria	Score A	Score B	Score C	Score D	Score E
Competition results (Championships)	1st individual winner	50	40	30	20	
	2nd individual winner	45	35	25	15	
	3rd individual winner	40	30	20	10	
	Individual Category Winner	32	24	16	8	

	1st team winner	40	30	20	10	
	2nd team winner	35	25	15	7	
	3rd team winner	30	20	10	6	
	Team Category Winner	24	16	10	5	
Awards	Merit Award	50	40	30	20	
	Competition Grant Recipient	40	30	20	10	
	(Grand Final, Gold Medal Winner based on Cutoff Score)	25	15	7	3	
	(Grand Final, Silver Medal Winner based on Cutoff Score)	20	10	5	2	
	Participation Certificate	10	5	3	1	
	Other	10	5	3	1	
Organizational Careers	Chairman	50	40	30	20	10
	Vice Chairman	45	35	25	15	8
	Secretary	40	30	20	10	6
	Treasurer	40	30	20	10	6
	One Level Below the Daily Management	30	20	10	5	2
	Member	1	1	1	1	1
Work Results	Patent			50		
	Simple Patent			30		
	Copyright			30		
	Book with ISBN, as Main Author			30		
	Book with ISBN, as second Author			20		
	Main Author/Correspondence of Scientific Work in a Reputable and Recognized Journal	50		30		50
	Second Author (not correspondence) etc. of scientific work in a Reputable and Recognized Journal	30		20		
Entrepreneurship		50	40	30	20	10

where A is the international level, B is the regional level, C is the national level, D is the provincial level, and E is the district/city/university level.

Analytical Hierarchy Process (AHP) Method

AHP is an approach method that is suitable for handling complex systems related to decision making from several alternatives and providing choices that can be considered. AHP has the following stages.

1. Creating a hierarchical structure

2. Forming a pairwise comparison matrix that describes the relative contribution or influence of each element to each objective or criterion at the level above it.

3. Normalizing the data by dividing the value of each element in the paired matrix by the total value of each column.

4. Calculating the eigenvector value and testing its consistency, if inconsistent, data collection (preference) needs to be repeated.

5. Repeating steps 3, 4, and 5 for all levels of the hierarchy.

6. Testing the consistency of the weights, testing is carried out in 3 stages, namely as shown in (1), (2), and (3).

$$t = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{i-th\ element\ on\ (A)(W^T)}{i-th\ element\ on\ (W^T)}\right) \quad (1)$$

$$CI = \frac{t-n}{n-1} \quad (2)$$

$$CR = \frac{CI}{RI_n} \quad (3)$$

If CI is 0, the weights are consistent. If CR < 0.1, the weights are fairly consistent. If CR > 0, the weights are inconsistent.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method

TOPSIS is one of the methods often used in decision-making cases. It has a concept where the selected alternative is the best alternative that has the shortest distance from the positive ideal solution and the distance from the negative ideal solution. TOPSIS has the following stages.

1. Create a decision matrix

2. Normalize the decision matrix.

The normalized decision matrix is formed by following equation.

$$r_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}^2} \quad (4)$$

3. Perform weighted normalization on the normalized decision matrix.

Create a weighted normalized decision matrix with the equation with equation (5).

$$y_{ij} = W_i \times r_{ij} \quad (5)$$

4. Determining positive and negative ideal solutions

The determination of positive and negative ideal solutions is determined based on the weighted normalized decision matrix using equation (6).

$A^+ = (y_1^+, y_2^+, \dots \dots y_n^+)$ (6)

$A^- = (y_1^-, y_2^+, \dots \dots y_n^-)$

5. Determining the distance between alternatives and positive and negative ideal solutions.

In determining the distance between alternatives and positive and negative ideal solutions, you can use equations (7) and (8).

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(y_i^+ - y_{ij})^2} \quad (7)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)^2} \quad (8)$$

6. Determining the preference value for each alternative.

Determining the preference value for each alternative based on equation (9)

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (9)$$

3 Result And Discussion

The process of selecting outstanding students at Trunojoyo University, Madura follows the National PILMAPRES Guidelines for Undergraduate Programs in 2024. There are several criteria included in the assessment, including competition results (championships), recognition, awards, organizational careers, work results, empowerment or humanitarian action, and entrepreneurship. However, in this study, the criteria taken were competition results (championships), recognition, awards, organizational careers, work results, and entrepreneurship. This data is adjusted to the conditions of the informatics education study program students collected.

3.1 Implementation of AHP Method

3.1.1 Determining the level of importance between criteria

The first stage in calculating the AHP method is determining the level of importance between the criteria used to create the pairwise comparison matrix. The level of importance between the criteria in this study is:

a. The criteria for the value of the work (C1) are equally important [1] compared to the criteria for the value of the competition (C2)
b. The criteria for the value of the work (C1) and the value of the competition (C2) are quite important [3] compared to the criteria for the value of the award (C3)
c. The criteria for the results of the work (C1), the value of the competition (C2), and the value of the award (C3) are more important [5] compared to the criteria for entrepreneurship (C4)
d. The criteria for the value of the work (C1) and the value of the competition (C2) are extremely important [9] compared to the value of the organizational career (C5)
e. The criteria for the value of the award (C3) are very important [5] compared to the value of the organizational career (C5)
f. The criteria for the value of entrepreneurship (C4) are quite important [3] compared to the value of the organizational career (C5)

3.1.2 Creating a pairwise comparison matrix of criteria

The creation of a pairwise comparison matrix between criteria is based on the previously defined level of importance. The decision matrix for the comparison of criteria is shown in following Table.

Table 3. Matrix for the Comparison of Criteria

	C1	C2	C3	C4	C5
C1	1	1	3.00	5	9
C2	1	1	3.00	5	9
C3	0.333	0.333	1	5	7
C4	0.2	0.2	0.2	1	3
C5	0.111	0.11	0.142	0.333	1
Total	2.644	2.644	7.342	16.333	29

3.1.3 Perform normalization on each paired matrix value

Normalization of the paired matrix values in Table 2 was carried out to make the value range 1 to 0. The results of the pairwise comparison are shown in Table 4.

Table 4. Result of pairwise comparison Matrix

	C1	C2	C3	C4	C5
C1	0.3782	0.3782	0.4086	0.3061	0.3103
C2	0.3782	0.3782	0.4086	0.3061	0.3103
C3	0.1261	0.1261	0.1362	0.3061	0.2414
C4	0.0756	0.0756	0.0272	0.0612	0.1034
C5	0.0420	0.0420	0.0195	0.0204	0.0345
Total	1	1	1	1	1

3.1.4 Determining the average value of the criteria matrix

The average value results are shown in table 4. The average values shown in Table 4 are used as the weights for the calculation of the TOPSIS method in making its weighted normalization. The weight values produced by the AHP method cannot be used directly, but must first be tested for consistency. The list of weights obtained from the AHP method is W = [0.3563, 0.3563, 0.1872, 0.0686, 0.0317]

Table 5. Average value of criteria

	C1	C2	C3	C4	C5	Average
C1	0.3782	0.3782	0.4086	0.3061	0.3103	0.3563
C2	0.3782	0.3782	0.4086	0.3061	0.3103	0.3563
C3	0.1261	0.1261	0.1362	0.3061	0.2414	0.1872
C4	0.0756	0.0756	0.0272	0.0612	0.1034	0.0686
C5	0.0420	0.0420	0.0195	0.0204	0.0345	0.0317

3.1.5 Finding the maximum lambda value

To obtain the maximum lambda value, it can be calculated using the matrix multiplication concept between the pairwise comparison matrix in Table 4 and the transpose weight value. The maximum lambda results are shown in Table 6.

Table 6. Maximum Lambda

	C1	C2	C3	C4	C5	W	Max Lambda
C1	0.3782	0.3782	0.4086	0.3061	0.3103	0.3563	1.9023
C2	0.3782	0.3782	0.4086	0.3061	0.3103	0.3563	1.9023
C3	0.1261	0.1261	0.1362	0.3061	0.2414	0.1872	0.9896
C4	0.0756	0.0756	0.0272	0.0612	0.1034	0.0686	0.3436
C5	0.0420	0.0420	0.0195	0.0204	0.0345	0.0317	0.1605

3.1.6 Finding the t-value

$$t = \frac{1}{5} \times \left(\left(\frac{1.9023}{0.3563} \right) + \left(\frac{1.9023}{0.3563} \right) + \left(\frac{0.9896}{0.1872} \right) + \left(\frac{0.3436}{0.0686} \right) + \left(\frac{0.1605}{0.0317} \right) \right) = 5.2076$$

3.1.7 Calculating Consistency Index

To calculate the consistency index, equation (2) is used.

$$CI = \frac{5.2076 - 5}{5 - 1} = 0.0519$$

3.1.8 Calculating Consistency Ratio

Calculation of consistency ratio value by dividing CI value by Random Index (RI) value. In this study, 5 criteria were used, so the RI value was 1,12. The CI calculation process uses the equation

$$\text{CR} = \frac{0.0519}{1.12} = 0.0463 \qquad (1)$$

The CR value obtained is 0.0463 < 0.1. This value proves that the weights obtained using the AHP method are said to be consistent so they can be used.

3.2 Implementation of TOPSIS Method

3.2.1 Creating alternative data and its criteria in the form of a decision matrix

The first stage is to create a decision matrix based on alternative data and the criteria for selecting outstanding students obtained from the questionnaire mentioned. The decision matrix is shown in following Table.

Table 7. Data Criteria of several alternatives

Alternative	Criteria				
	C1	C2	C3	C4	C5
M1	90	50	0	0	7
M2	0	0	0	0	10
M3	0	0	0	0	2

M4	30	0	0	0	3
M5	30	40	0	0	1
M6	30	10	0	0	3
M7	30	0	0	0	3
M8	30	40	0	0	4
M9	60	60	0	0	10
M10	0	0	0	0	2
M11	0	0	0	0	2
M12	0	0	0	0	2
M13	0	0	0	10	2
M14	0	0	0	10	2
M15	0	90	0	10	0
M16	30	0	0	0	3
M17	0	0	0	0	2
M18	0	30	0	0	0
M19	0	120	0	10	2
M20	0	60	0	10	1
M21	0	0	10	10	6
M22	0	30	0	0	0
M23	30	0	0	0	12
M24	0	0	0	0	4
M25	0	90	0	10	28

3.2.2 Making a normalized decision matrix

The results of the decision matrix normalization are shown in Table 8

Table 8. Matrix Normalization

Alternative	Criteria				
	C1	C2	C3	C4	C5
M1	0.2500	0.0806	0	0	0.0631
M2	0	0	0	0	0.0901
M3	0	0	0	0	0.0180
M4	0.0833	0	0	0	0.0270
M5	0.0833	0.0645	0	0	0.0090
M6	0.0833	0.0161	0	0	0.0270
M7	0.0833	0.0000	0	0	0.0270
M8	0.0833	0.0645	0	0	0.0360
M9	0.1667	0.0968	0	0	0.0901
M10	0	0	0	0	0.0180
M11	0	0	0	0	0.0180
M12	0	0	0	0	0.0180
M13	0	0	0	0.1429	0.0180
M14	0	0	0	0.1429	0.0180
M15	0	0.1452	0	0.1429	0.0000
M16	0.0833	0	0	0	0.0270
M17	0	0	0	0	0.0180

M18	0	0.0484	0	0	0
M19	0	0.1935	0	0.1429	0.0180
M20	0	0.0968	0	0.1429	0.0090
M21	0	0	1.0000	0.1429	0.0541
M22	0	0.0484	0	0	0
M23	0.0833	0	0	0	0.1081
M24	0	0	0	0	0.0360
M25	0	0.1452	0	0.1429	0.2523

3.2.3. Create a weighted normalized matrix

Calculation of the weighted normalized matrix by multiplying the value of each alternative in the normalized decision matrix by the weight value resulting from the AHP method. The results of the weighted normalized decision matrix are shown in Table 9.

Table 9. Weighted Normalized Matrix

Alternative	Criteria				
	C1	C2	C3	C4	C5
M1	0.0891	0.0287	0	0	0.0020
M2	0	0	0	0	0.0029
M3	0	0	0	0	0.0006
M4	0.0297	0	0	0	0.0009
M5	0.0297	0.0230	0	0	0.0003
M6	0.0297	0.0057	0	0	0.0009
M7	0.0297	0	0	0	0.0009
M8	0.0297	0.0230	0	0	0.0011
M9	0.0594	0.0345	0	0	0.0029
M10	0	0	0	0	0.0006
M11	0	0	0	0	0.0006
M12	0	0	0	0	0.0006
M13	0	0	0	0.0098	0.0006
M14	0	0	0	0.0098	0.0006
M15	0	0.0517	0	0.0098	0
M16	0.0297	0	0	0	0.0009
M17	0	0	0	0	0.0006
M18	0	0.0172	0	0	0
M19	0	0.0690	0	0.0098	0.0006
M20	0	0.0345	0	0.0098	0.0003
M21	0	0	0.1872	0.0098	0.0017
M22	0	0.0172	0	0	0
M23	0.0297	0	0	0	0.0034
M24	0	0	0	0	0.0011
M25	0	0.0517	0	0.0098	0.0080

3.2.4 Determining the matrix of positive ideal solutions and negative ideal solutions

Table 10. Matrix of positive ideal solutions and negative ideal solut

	C1	C2	C3	C4	C5
A+	0.0891	0.0690	0.1872	0.0098	0.0080
A-	0	0	0	0	0

3.2.5 Determine the distance between the positive ideal solution and the negative ideal solution.

Table 11. Matrix of positive ideal solutions and negative ideal solutions

Alternative	Distance Ideal Solution	
	D+	D-
M1	0.1918	0.0936
M2	0.2187	0.0029
M3	0.2188	0.0006
M4	0.2085	0.0297
M5	0.2020	0.0375
M6	0.2066	0.0303
M7	0.2085	0.0297
M8	0.2020	0.0376
M9	0.1929	0.0687
M10	0.2188	0.0006
M11	0.2188	0.0006
M12	0.2188	0.0006
M13	0.2186	0.0098
M14	0.2186	0.0098
M15	0.2081	0.0526
M16	0.2085	0.0297
M17	0.2188	0.0006
M18	0.2140	0.0172
M19	0.2074	0.0697
M20	0.2103	0.0358
M21	0.1128	0.1874
M22	0.2140	0.0172
M23	0.2084	0.0299
M24	0.2188	0.0011
M25	0.2080	0.0532

3.2.6 Determine preference values

Table 12. Result of preference value

Alternative	Result
M1	0.3280
M2	0.0129
M3	0.0026
M4	0.1247

M5	0.1567
M6	0.1277
M7	0.1247
M8	0.1568
M9	0.2626
M10	0.0026
M11	0.0026
M12	0.0026
M13	0.0430
M14	0.0430
M15	0.2018
M16	0.1247
M17	0.0026
M18	0.0745
M19	0.2514
M20	0.1457
M21	0.6242
M22	0.0745
M23	0.1254
M24	0.0052
M25	0.2038

3.2.7 Ranking

The final results obtained using the TOPSIS method, ranking is done based on the highest value of each prospective outstanding or alternative student. The ranking results are shown in following Table.

Table 13. Final Result of rangking

Alternative	Final Result
M21	0.6242
M1	0.3280
M9	0.2626
M19	0.2514
M25	0.2038

It is found in Table x that when the final results have been sorted from the largest to the smallest, it can be seen that the top ranking is occupied by M2 with a final value of 0.6242. With this recommendation system, the decision to recommend becoming a representative of the informatics education study program to participate in the outstanding student event can facilitate and accelerate the study program in making decisions. The results of the validation of calculations by system and manual methods produce the same alternative ranking results.

4 Conclusion

Outstanding students is an event aimed at providing learning motivation for students to compete to achieve an achievement in both academic and non-academic fields. In this event,

several selections are carried out where there are several criteria that must be met by an outstanding student. Not only one criterion but several criteria that allow for sequential and manual checking will take a lot of time. In the implementation of the AHP method, a CR value of 0.046348 was obtained, which proves that the weighting level of the predetermined criteria can be said to be consistent. Then, in the next stage, namely the implementation of TOPSIS. The final value of 0.6242 was obtained in the name of M2 occupying the top ranking of other names included in the list of prospective outstanding students. The AHP and TOPSIS methods can be used to evaluate student criteria data into recommendations for outstanding students based on certain preferences.

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