Performa: Media Ilmiah Teknik Industri
ISSN 1412-8624 (print) | ISSN 2620-6412 (online)
Vol. 21, No. 1, 2022, Page. 105-112
doi.org/10.20961/performa.21.1.60307

Decision Support System to Select Elective Courses Using Hybrid AHP-PROMETHEE Method

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Abstract

The selection of elective courses is often confusing for students as indicated by the initial survey of class 2015 -2018 students in the Informatics Department of Sebelas Maret University which showed that 88,9% needed a system to assist in selecting elective courses. This study was conducted to accommodate students' requirements by designing the decision support system to recommend elective courses by combining AHP and PROMETHEE methods. AHP was used to weight the criteria, after which they were then ranked using the PROMETHEE such that the elective courses were sorted partially using PROMETHEE I as scenario 1 and completely through PROMETHEE II as scenario 2. The accuracy test showed that scenarios 1 and 2 were 67.4% and 60.4%, respectively, accurate.

Keywords: courses recommendation, AHP, Promethee, university student

Abstract

Pemilihan mata kuliah pilihan seringkali membingungkan mahasiswa sebagaimana ditunjukkan oleh survey awal terhadap mahasiswa Jurusan Teknik Informatika Universitas Sebelas Maret angkatan 2015 - 2018, yang menunjukkan bahwa 88,9% membutuhkan sistem untuk membantu dalam pemilihan mata kuliah pilihan. Penelitian ini dilakukan untuk mengakomodir kebutuhan mahasiswa dengan merancang sistem pendukung keputusan untuk merekomendasikan mata kuliah pilihan dengan menggabungkan metode AHP dan PROMETHEE. AHP digunakan untuk pembobotan kriteria, kemudian diranking menggunakan PROMETHEE. Mata kuliah pilihan diurutkan secara parsial menggunakan PROMETHEE I sebagai skenario 1 dan diurutkan secara lengkap dengan PROMETHEE II sebagai skenario 2. Uji akurasi menunjukkan bahwa skenario 1 menunjukkan akurasi 67,4% dan skenario II akurasinya adalah 60,4%.

Kata kunci: rekomendasi, matakuliah, studi kasus, mahasiswa

1. Introduction

The selection of elective courses is often an important thing due to its importance in determining student careers (Onay et al., 2016) but the process is considered to be difficult by students (Hancerliogullari Koksalmis, 2019). This is associated with the lack of appropriate information and awareness on the suitability of the courses in relation to their academic potential (Bedir et al., 2016). This problem was observed in the Informatics Departement of Sebelas Maret University (UNS) which currently has a total of 123 credits (SKS) required to be completed within eight semesters according to the 2016 curriculum.

A survey conducted to the class of 2015-2018 showed that 88.9% of students need assistance in selecting elective courses due to the lack of adequate information. This spurred the administrator of the departement to conduct further studies directed towards building a model to support decision-making in selecting courses.

On the past research, selecting elective courses could be achieved using the Multiple Criteria Decision Making (MCDM) method which includes the Analytic Hierarchy Process (AHP) (Promentilla et al., 2018), Fuzzy AHP (Onay et al., 2016; Huang, 2015), Technique Order Preference by Similarity To Ideal Solution/TOPSIS (Rahayu, 2020), and AHP-PROMETHEE (Bedir et al., 2016).

There are also different criteria or variables to make elective course decisions, among others Hancerliogullari (2019) led to the application of five criteria by which include the class schedules, teaching staff, course content, course requirements, and peer factors. These were further summarized by Al-Sarem (2017) into three main groups which are the course, social, and individual aspects. Moreover, a study conducted at the Kirikkale University Graduate

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Received 27 March 2022; Received in revised form 28 March 2022; Accepted 6 April 2022

School of Natural and Applied Sciences used courses, schedules, lecturer attitudes, student interest, and academic expectations of the course as the decision criteria to select a course (Bedir et al., 2016).

The Decision Support System investigated in previous studies only proved that the model was successfully built through the application of the selected method, but the accuracy level of the system's output was not calculated. It is also important to note that the comprehensive combination of AHP and PROMETHEE is still rare.

The AHP method is beneficial in weighting criteria due to its ability to check for consistency (Latuny, Paillin, & Yaniah, 2020) but is weak in algorithms ranking (Apriani, Priadythama, & Herdiman, 2019). Meanwhile, the PROMETHEE method can rank algorithm with adjustments, but it is unable to weigh the criteria due to its inability to check for consistency (Lemantara *et al.*, 2013). The combination of these two methods can be used to produce a more optimal ranking order of alternatives with AHP applied to weigh the criteria (Capryani, Nugroho, & Saputri, 2016) while PROMETHEE is for the ranking.

Bedir et al., (2016) succeeded in combining these two methods to examine the decision-making model for elective courses but only general AHP and PROMETHEE were used. PROMETHEE can be applied to partial or complete scenarios with the effectiveness of the model compared to support the decision-making process.

This study attempts to fill the gap between the problems by examining the application of AHP and PROMETHEE I (partial) as well as AHP and PROMETHEE II (complete) in the Decision Support System to select elective courses. Furthermore, the accuracy level of the system in the ranking results was calculated and compared. The findings are used to recommend the order of the elective courses according to the semester choices and student input into the system. Furthermore, the recommendations are expected to assist students during the process of selecting elective courses.

2. Methods

This section describes the stages involved in this study as well as methods to develop a decision support system model for elective courses. It is important to note that the Informatics Department of Sebelas Maret University was used as the case study.

The model development stage consists of four steps including the data collection, weighing using the AHP method, ranking of attributes through PROMETHEE I and II, as well as the testing and analysis of data. These stages are shown in the Figure 1.

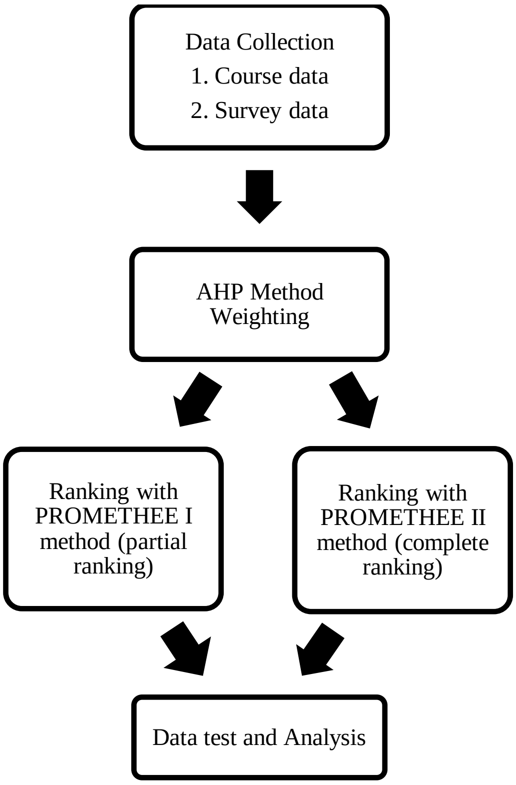

Figure 1. Study method

These stages are further described in the following sub-chapters:

2.1. Data Collection

Data on the elective courses in the Study Program online document were retrieved using surveys such as interviews and the distribution of questionnaires to students class of 2015-2018. The stages involved are also indicated as follows:

Elective course data collection

This activity was conducted by accessing the website of the Informatics Study Program, Sebelas Maret University (https://if.mipa.uns.ac.id/akademik/kurikulum/) with the page observed to have a list containing the semester, course code, course name, prerequisite courses, and credits for each elective course. Furthermore, the data and name of the lecturer for the elective course can be obtained from the website (https://jadwal.uns.ac.id/).

Survey data collection

The survey was conducted by distributing online questionnaires to the students of class 2015 - 2018. Meanwhile, the samples were selected using the Slovin formula (Sevilla, 2007).

$$n = \frac{N}{1+Ne^2} \quad (1)$$

Where: n = number of samples
N = number of populations
e = error tolerance limit

$$n = \frac{328}{1 + (328 \text{ X } 0.15^2)}$$
$$n = 39{,}14 \approx 40$$

This means a total of 40 students were used as samples in developing the Decision Support System to select elective courses. Data were collected twice with the first stage focused on determining the criteria or factors influencing students in selecting elective courses. This was achieved by combining the data obtained from the survey questionnaire and a review of related journals.

The second stage focused on collecting data on scores processed in the Decision Support System by distributing questionnaires to respondents. The data obtained contains personal profiles, comparison scores between criteria, comparison scores between criteria and elective courses, and a list of elective courses selected by students.

2.2 Weighting with AHP Method

This stage focuses on weighting the criteria using the AHP method through the steps shown in Figure 2.

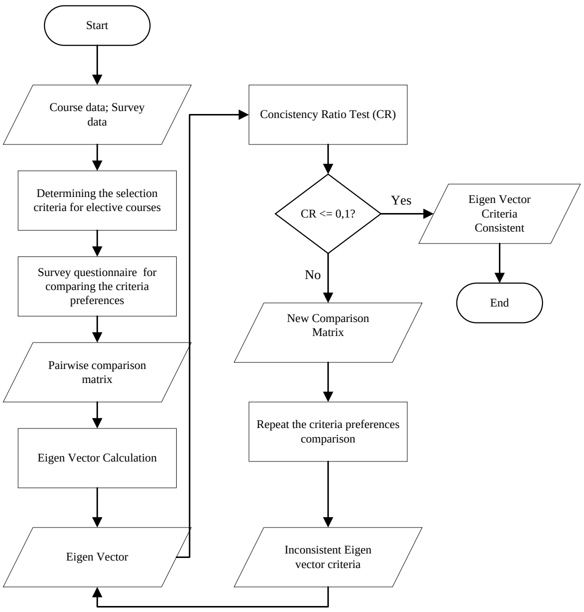

Figure 2. Flowchart of the AHP method process

Furthermore, the eigenvectors are calculated with the process steps shown in Figure 3.

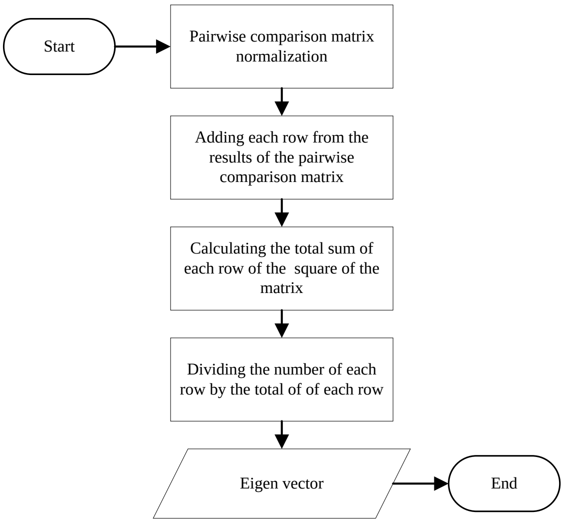

Figure 3. Flowchart of the AHP method eigenvector process

The next stage is to test the consistency of the AHP method with the steps described in Figure 4 to ensure its applicability in generating the weight of the criteria (eigenvectors).

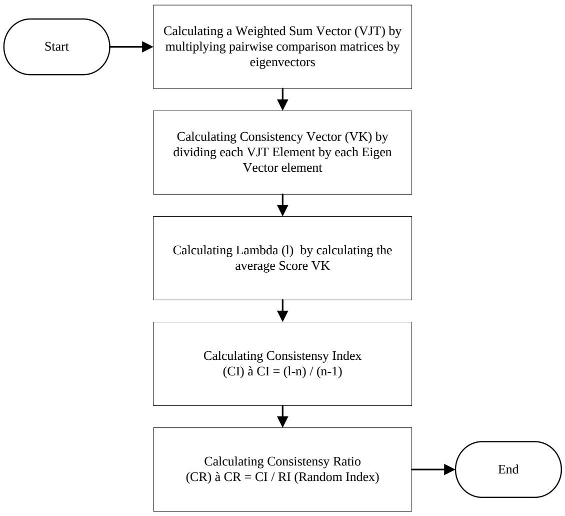

Figure 4. Flowchart of the consistency test process with the AHP method

2.5. Ranking with PROMETHEE I and II Methods

This stage focused on ranking the alternative elective courses using the PROMETHEE I and II methods as indicated in the following Figure 5.

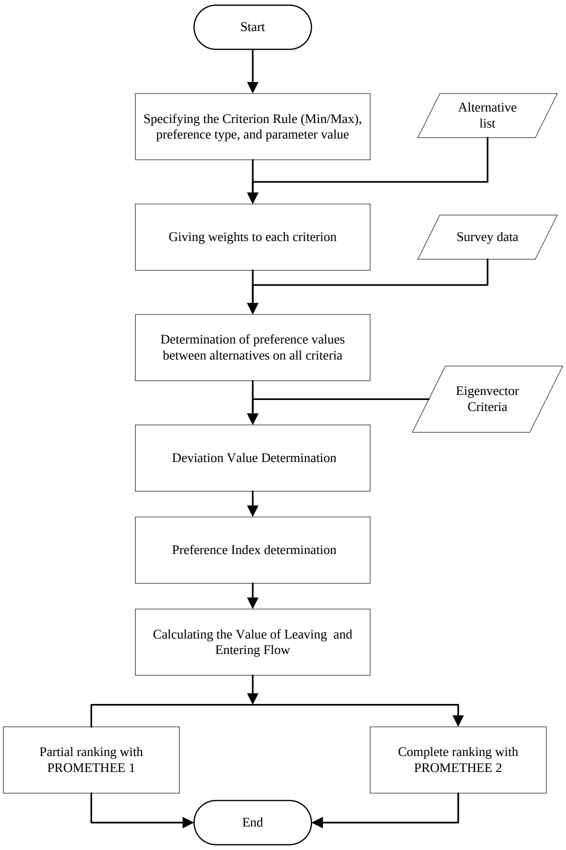

Figure 5. Flowchart of the PROMETHEE method process

2.6. Test and Analysis

This stage was used to test the possibility of using the results from implementing the AHP as well as PROMETHEE I and II methods for the decision support system as a reference for students in selecting elective courses through the accuracy-test according to the following equation (Liu, 2011):

$$Accuracy = \frac{Amount\ of\ test\ data}{Total\ test\ data} \tag{2}$$

The test scenario was used to calculate the amount of data with a match between the recommendation order produced from the system and the data on the elective courses taken by students. The accuracy of the two scenarios was determined, firstly, using the AHP and PROMETHEE I methods (scenario 1) and, secondly, through the AHP and PROMETHEE II methods (scenario 2). The results were compared and analyzed to make conclusions.

3. Results and Discussion

The data showed 71 credits of elective courses and 25 courses available for students to select. The weighting process was conducted using the AHP method as indicated in the following 9 steps:

Step 1: Criteria to select elective courses in the decision support system as follows:

K1 - Interested in Courses and these include the selection of elective courses based on interest, specialization, and expertise.
K2 - Usefulness of Courses in the Real World which includes the selection based on the usefulness of the elective courses in the real world such as those often used and easy to be applied in the field of work.
K3 - Lecturer Factor which includes selection based on the attributes of the lecturer such as the teaching style, relationships with students, and giving grades.
K4 - Environment Factor which focuses on the selection based on the influence of the environment such as peer pressure and experience of students who have previously taken the course.
K5 - Previous semester's GPA is based on the selection of the course based on the previous GPA of students considering its effect on the number of credits allowed to select in the following semester.

Step 2: Determination of Comparison Scores between Criteria. The pairwise comparison between the criteria was conducted based on the data from the survey data using a range of scores from 1 to 9 according to the quantitative scale in the AHP method (Saaty, 1987) as shown in Table 1.

Table 1. Comparison scores between criteria

Pairwise comparisons between criteria	Comparison Scores
K1 – K2	1
K1 – K3	2
K1 – K4	3
K1 – K5	5
K2 – K3	4
K2 – K4	5
K2 – K5	7
K3 – K4	4
K3 – K5	7
K4 – K5	5

Step 3: Formation of a pairwise comparison matrix between criteria as shown in Table 2.

Table 2. Criteria paired matrix

	K1	K2	K3	K4	K5
K1	1	1	2	3	5
K2	1	1	4	5	7
K3	0.5	0.25	1	4	7
K4	0.33	0.2	0.25	1	5
K5	0.2	0.14	0.14	0.2	1
Total	3.03	2.59	7.39	13.2	25

Step 4: Calculation of Eigen Values and Eigen Vectors by normalizing the matrix in Table 3.

Table 3. Normalization of criteria matrix

	K1	K2	K3	K4	K5
K1	0.329	0.385	0.27	0.227	0.2
K2	0.329	0.385	0.541	0.378	0.28
K3	0.164	0.096	0.135	0.303	0.28
K4	0.109	0.077	0.033	0.075	0.2
K5	0.065	0.055	0.019	0.015	0.04

Step 5: Determination of the eigenvector values by dividing the number of each row by the total number of each row as indicated in Table 4.

Table 4. Normalization of eigenvector values

	K1	K2	K3	K4	K5	Number	Eigen vector
K1	0.329	0.385	0.27	0.227	0.2	1.413	0.282
K2	0.329	0.385	0.541	0.378	0.28	1.915	0.383
K3	0.164	0.096	0.135	0.303	0.28	0.979	0.195
K4	0.109	0.077	0.033	0.075	0.2	0.496	0.099
K5	0.065	0.055	0.019	0.015	0.04	0.195	0.039
Total	1	1	1	1	1	5	1

Step 6: Consistency Test conducted determined through the Weighted Amount Vector (VJT) which involves multiplying the criteria in the paired comparison matrix with the eigenvectors and the results are presented in Table 5.

Table 5. Weighted amount vector

Criteria	VJT
K1	1.55
K2	2.219
K3	1.103
K4	0.514
K5	0.198

Step 7: Calculation of the Consistency Vector (VK) by dividing each VJT element with each eigenvector element, and the results are presented in Table 6.

Table 6. Consistency Vector

Criteria	VK
K1	5.547
K2	5.794
K3	5.635
K4	5.182
K5	5.068

Step 8: Calculation of maximum Eigenvalue (λ_{max}), consistency index, and consistency ratio (CR)

Maximum eigen (λ_{maks}) :

$$\lambda_{max} = \frac{VK}{n} \quad (3)$$

$$\lambda_{max} = \frac{27.167}{5}$$

$$\lambda_{max} = 5.433$$

Consistency index:

$$\text{CI} = \frac{\lambda\text{max} - \text{n}}{n-1} \quad (4)$$

$$\text{CI} = \frac{5.433 - 5}{5-1}$$

$$\text{CI} = 0.108$$

Consistency ratio (CR):

Where: $n = 5$

RI = 1.12

$$\text{CR} = \frac{\text{CI}}{RI} \quad (5)$$

$$\text{CR} = \frac{0.108}{1.12}$$

$$\text{CR} = 0.096$$

Step 9: Evaluation of the Consistency Ratio (CR) and this involved providing the CR with a value equal to or less than 0.100 (10%). The comparison between criteria is considered inconsistent and needs to be repeated when the CR value exceeds this limit. Meanwhile, the CR was found to be 0.096 <0.1, thereby, indicating the weight of the criteria is consistent and can be used in the next stage.

The criteria weights determined through the eigenvector matrix values are, presented in Table 7.

Table 7. Criteria weight

Criteria	Weight
K1	0.283
K2	0.383
K3	0.196
K4	0.099
K5	0.039

A ranking process was conducted after the AHP weighting using the PROMETHEE I method through the following six steps:

Step 1: Defining the Criteria Rule (min/max), Preference Type, and Parameter Value. Each criterion used in this study is qualitative with a scale level of 1 – 5 points such that the type I (usual) function is a good choice while type IV preference function (level) is considered suitable to distinguish a smaller deviation from a larger one (Deshmukh, 2013). The criterion rule used was due to the fact that greater points usually produce better alternative results.

Step 2: Forming a Data Matrix that contains the criteria, weight of each criterion, and alternatives considered. The weight of criteria used were the results obtained from the AHP method process and subsequently applied to determine the preference value between alternatives on each criterion in the range of 1 – 5. The PROMETHEE data matrix results are presented in the following Table 8.

Table 8. PROMETHEE data matrix

Alternative	Criteria				
	K1	K2	K3	K4	K5
Max/Min	Max	Max	Max	Max	Max
Multimedia Engineering (TM)	3	3	3	4	4
Computer Graphics (KG)	3	3	3	3	3
Open Source (OS)	5	4	5	5	5
Weight	0.283	0.383	0.196	0.099	0.039

Step 3: Determining the Preference Index by calculating the deviation value as indicated in the Table 9.

Table 9. Deviation Value

Alternative	CRITERIA				
	K1	K2	K3	K4	K5
Weight	**0.283**	**0.383**	**0.196**	**0.099**	**0.039**
Max/Min	**Max**	**Max**	**Max**	**Max**	**Max**
TM-KG	0	0	0	0.5	0.5
TM-OS	-1	-1	-1	-0.5	-0.5
KG-TM	0	0	0	-0.5	-0.5
KG-OS	-1	-1	-1	-1	-1
OS-TM	1	1	1	0.5	0.5
OS-KG	1	1	1	1	1

Step 4: Determining the Preference Index according to the type I (usual) function using the following relationship:

$$p(x) = \begin{cases} 0 & \forall_x \leq 0, \\ 1 & \forall_x > 0, \end{cases} \qquad (6)$$

The results are presented in Table 10.

Table 10. Preference Index

Alternative	CRITERIA					Number
	K1	K2	K3	K4	K5	
TM-KG	0	0	0	0.099	0.039	0.138
TM-OS	0	0	0	0	0	0
KG-TM	0	0	0	0	0	0
KG-OS	0	0	0	0	0	0
OS-TM	0.282	0.383	0.195	0.099	0.039	1
OS-KG	0.282	0.383	0.195	0.099	0.039	1

Step 5: Calculating the Leaving flow (ϕ^{+}) and entering flow (ϕ^{-}) using the following equation.

$$\phi^{-}(a) = \frac{1}{n-1} \sum \pi(x, a). \qquad (7)$$

The results are shown in Table 15.

Table 15. Leaving flow & entering flow

Alternative	TM	KG	OS	(ϕ^{+})
TM	-	0.138	0	0.046
KG	0	-	0	0
OS	1	1	-	0.667
(ϕ^{-})	0.333	0.379	0	

Step 6: Ranking using the PROMETHEE I method (partial ranking) with the best alternative determined through the largest leaving flow and smallest entering flow values. The results are presented in Table 16.

Table 16. Ranking with PROMETHEE I

Alternative	(ϕ^{+})	Ranking	(ϕ^{-})	Ranking	Alternative Ranking
TM	0.046	2	0.333	2	2
KG	0	3	0.379	3	3
OS	0.667	1	0	1	1

The PROMETHEE II mechanism (complete) ranking was analyzed based on the order of the largest to the smallest net flow. Meanwhile, the net flow was obtained from the leaving flow value minus the entering flow value as indicated in the following equation:

$$\phi(a) = \phi^{+}(a) - \phi^{-}(a), \qquad (8)$$

The results of the alternative ranking are indicated in the following Table 17.

Table 17. Net flow

Alternative	Net flow	Rank
TM	-0.287	2
KG	-0.379	3
OS	0.667	1

The alternative order with the largest net flow value was selected to be the first order based on PROMETHEE II as indicated in Table 18.

Table 18. Alternative order with PROMETHEE II

Ranking	Alternative
1	Open Source
2	Multimedia Engineering
3	Computer Graphics

The determination of the ranking results was followed by the calculation of the accuracy level between the system results and the elective courses selected by each student based on the following two scenarios:

Scenario 1: Test with AHP and PROMETHEE I Methods

The accuracy was determined using Equation 1 and the results showed that 15 out of 43 students were "Inappropriate" while the remaining 28 were "Appropriate". Therefore, the AHP and PROMETHEE I methods have an accuracy value of 0.674 or 67.4%.

Scenario 2: Test with AHP and PROMETHEE II Methods

The same equation was applied, and the results showed that 17 out of 43 students were "Inappropriate" while the remaining 26 were "Appropriate". Therefore, the AHP and PROMETHEE II methods have an accuracy value of 0.604 or 60.4%.

These results indicated that the accuracy of both scenarios is low due to the following factors:

1. The input data in the system was obtained from a student survey conducted only once through an online questionnaire.
2. The input in the form of pairwise comparison data between criteria used in the calculation with the AHP method only showed 3 students have a Consistency Ratio (CR) value < 0.1 (10%) which is declared consistent. This means the criteria weighting results are less consistent and not optimal.
3. The calculation through the PROMETHEE method showed that the input value of the alternative preference for elective courses greatly influenced the final result of the alternative order. However, the lack of knowledge caused several students to carelessly fill in the same value. This means some data have more than one course with the same ranking in the alternative order results.
4. Scenario 1 has higher accuracy than scenario 2 because only one system output is the best alternative with one elective course according to the data from the survey and this means there is no need to compare several alternatives in the suitability test. However, this scenario only produced one best alternative and does not display the full order.
5. The output of the system in scenario 2 is a complete order of elective courses ranked in the top three in this study and checked for their suitability with the data from the survey. Therefore, the data is considered inappropriate when the output of the system contains elective courses that are different from those obtained in the survey.

4. Conclusion

This study developed a Decision Support System for Elective Course Selection using the AHP and PROMETHEE methods. The AHP was applied to weigh the criteria, while PROMETHEE was used for the ranking. Moreover, a partial ranking of the elective courses was conducted using PROMETHEE I, while a complete ranking of alternative elective courses was determined through PROMETHEE II. The accuracy test showed the ranking result obtained from using AHP and PROMETHEE I (scenario 1) was 67.4% while AHP and PROMETHEE II (scenario 2) was 60.4%. This means the accuracy of scenario 1 is better than scenario 2, and it also only produced one best alternative for elective courses, while scenario 2 produced a complete alternative order.

This study succeeded in providing a model for the decision-making process by combining the AHP and PROMETHEE methods to process student input and produce a more objective and consistent system to assist students in selecting elective courses. However, there are some shortcomings that need to be resolved in further studies, including:

1. The criteria data need to be added and adapted more to the varied criteria for student needs to provide higher accuracy results.
2. Further studies can use the combination of other potentially more optimal methods including fuzzy-AHP and PROMETHEE.

References

Al-Sarem, M. (2017). Solving course selection problem by a combination of correlation analysis and analytic hierarchy process. *International Journal of Electrical and Computer Engineering*, *7*(6), 3536–3551. https://doi.org/10.11591/ijece.v7i6.pp3536-3551

Apriani, D. H., Priadythama, I., & Herdiman, L. (2019). Penentuan Kriteria Pembangun Performansi pada Fiksator Eksternal Berbasis Hexapod menggunakan Pendekatan Delphi-AHP. *Performa: Media Ilmiah Teknik Industri*, *18*(1), 58–64. https://doi.org/10.20961/performa.18.1.18968

Bedir, N., Özder, E. H., & Eren, T. (2016). Course Selection with AHP & PROMETHEE Methods for Post Graduate Students: An Application in Kirikkale University Graduate School of Natural and Applied Sciences. *MATEC Web of Conferences*, *68*, 4–10. https://doi.org/10.1051/matecconf/20166820004

Capryani, A., Nugroho, A. W., Saputri, V. H. L., & -, Y. (2016). Pemilihan Lokasi Kantor Menggunakan Metode Analytical Hierarchy Process (AHP) (Studi Kasus: PT. Monang Sianipar Abadi Surakarta). *PERFORMA : Media Ilmiah Teknik Industri*, *15*(1), 26–34. https://doi.org/10.20961/performa.15.1.13744

Deshmukh, S. C. (2013). Preference Ranking Organization Method Of Enrichment Evaluation (Promethee). *International Journal of Engineering Science Invention*, *2*(11), 28–34.

Hancerliogullari Koksalmis, G. (2019). Factors Affecting Selection of Elective Courses: The Use of Multi-Criteria Decision Making Model. *Journal of Business Administration Research*, *1*(1), 1–7. https://doi.org/10.30564/jbar.v1i1.205

Huang, C. (2015). Analytic hierarchy process-based university students sports elective course development and influence factors research. *Open Cybernetics and Systemics Journal*, *9*, 2108–2113. https://doi.org/10.2174/1874110X01509012108

Latuny, W., Paillin, D. B., & Yaniah, S. (2020). Kombinasi Analytical Hierarchy Process (AHP) dan Data Envelopment Analysis (DEA) untuk Pemilihan Supplier Pada UD. Jepara Putra Mebel. *Performa: Media Ilmiah Teknik Industri*, *19*(2), 141–150. https://doi.org/10.20961/performa.19.2.46324

Lemantara, J., Setiawan, N. A., & Aji, M. N. (2013). Rancang Bangun Sistem Pendukung Keputusan Pemilihan Mahasiswa Berprestasi Menggunakan Metode AHP dan Promethee. *Jnteti*, *2*(4), 20–28.

Liu, B. (2011). *Web Data Mining : Exploring Hiperlinks, Contents, and Usage Data* (M. J. Carey & S. Ceri (eds.); Second). Springer-Verlag Berlin Heidelberg. https://doi.org/10.1007/978-3-642-19460-3

Onay, A., Karamaşa, Ç., & Saraç, B. (2016). Application of fuzzy AHP in selection of accounting elective courses in undergraduate and graduate Level. *Journal of Accounting, Finance and Auditing Studies*, *2*(4), 20–42. http://www.aacsb.edu/

Promentilla, M. A. B., Aviso, K. B., Lucas, R. I. G., Razon, L. F., & Tan, R. R. (2018). Teaching Analytic

Hierarchy Process (AHP) in undergraduate chemical engineering courses. *Education for Chemical Engineers*, *23*, 34–41. https://doi.org/10.1016/j.ece.2018.05.002

Rahayu, A. (2020). Decision Support System for Elective Course Selection Using the TOPSIS Method. *Journal of Intelligent Decision Support System (IDSS)*, *3*(2), 7. https://doi.org/10.31253/te.v4i1.432

Saaty, R. W. (1987). The Analytic Hierarchy Process – What It Is and How It Is Used. *Mathematical Modelling*, *9*, 161–176. https://doi.org/10.1016/0270-0255(87)90473-8

Sevilla, C. (2007). *Research Methods*. Rex Printing Company. Quezon City