Available at https://jtsiskom.undip.ac.id (31 January 2022)
DOI:10.14710/jtsiskom.2022.14074

Jurnal Teknologi dan Sistem Komputer, 10(1), 2022, 20-25

TATOPSIS: A decision support system for selecting a major in university with a two-way approach and TOPSIS

Dewi Wardani[1*)], Widyaswari Mahayanti[1)], Haryono Setyadi[1)], Maria Ulfa[2)], Endar Wihidayat[3)]

[1)]*Informatics Department, Faculty of Mathematics and Natural Science, Universitas Sebelas Maret*
Jl. Ir Sutami 36 A, Surakarta, Central Java 57126, Indonesia

[2)]*Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret*
Jl. Ir Sutami 36 A, Surakarta, Central Java 57126, Indonesia

[3)]*Department of Informatics and Computer Technology Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret*
Jl. Ir Sutami 36 A, Surakarta, Central Java 57126, Indonesia

How to cite: D. Wardani, W. Mahayanti, H. Setiadi, M. Ulfa, and E. Wihidayat, "TATOPSIS: A decision support system for selecting a major in university with a two-way approach and TOPSIS," *Jurnal Teknologi dan Sistem Komputer*, vol. 10, no. 1, pp. 20-25, 2022. doi: 10.14710/jtsiskom.2022.14074, [Online].

Abstract – Several problems can occur when students feel they have made the wrong choice of major in university. Choosing a major is one of the problems that students often face. Therefore, this study aims to develop a Decision Support System (DSS) to help students find majors that match their interests and abilities. This DSS proposes a two-way approach by considering students and the major's requirements, standards, and characteristics. The DSS utilizes the TOPSIS method; therefore, it is called TATOPSIS, which stands for Two-way Approach TOPSIS. It showed that the two-way approach in Scenario 1 (without score normalization) and Scenario 3 (with score normalization) shows better agreement results in 78.33% and 73.33% than the two-way approach for Scenario 2, Scenario 4, and the student-one-way approaches.

Keywords *– decision support system; major selection; TOPSIS; two-way approach*

I. Introduction

Mistakes in choosing university majors can adversely impact students [1], [2]. Students usually experience problems related to psychological, academic, and relational problems [3]. A psychological problem is indicated by uncomfortable feelings when learning subjects that are not following interests and abilities. An academic problem is indicated by poor academic performance. A relational problem appears when student isolates from the environment because they feel uncomfortable.

Various studies indicate that selecting a major becomes one of the most common student problems [4]-[8]. These problems encourage researchers to develop a Decision Support System (DSS) for selecting majors using various methods and criteria [9]-[12]. Ananta et al. [10] have successfully built the DSS for selecting majors using the Dempster-Shafer method, providing recommendations based on students' interests and talent based on their psychological test results. The criteria used by Pare [13] are students' grades from their report cards and the result of Mathematics and Natural Science and language ability tests. Khuntari and Ferdiana [14] use a user preference approach in which the user weights each criterion. It uses three criteria: students' grades, interests, and desired majors. Bahaweres et al. [15] use five criteria: future goals, interests, suggestions, grades, and financial capabilities. It concludes that future goals are the most important criteria, followed by interests, grades, financial capabilities, and suggestions. However, there has not been an evaluation of the recommendation system that can show the recommendation's accuracy and the user satisfaction level.

Moreover, Prabowo and Sunyoto [16] built a DSS for selecting majors using a Profile Matching method. Meanwhile, other researcher uses the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, which has been proven to solve several problems [17]–[19]. Combining TOPSIS with the other methods for specific goals also shows promising results [20]–[26].

The TOPSIS considers not only a condition of the closest distance but also the farthest distance. So, the assessment becomes more efficacious [27]. The TOPSIS attempts to choose an alternative simultaneously with the closest distance from the positive ideal solution and the farthest distance from the negative ideal solution [28]. Alternative selection based on positive and negative ideal solutions is only found in the TOPSIS method and not in the other methods. From this characteristic, TOPSIS can be used to perform both positive and negative distance calculations from both ways: student-way and major-way. Recently, Wardani et al. [29] also proposed choosing a major based on considering a part of Holland Code talent classification and the previous performance of each student. This work does not consider the department's decision. It considers that when choosing a university major, the student's grade is not the sole factor but also the department of major.

*) Corresponding author (Dewi Wardani)
Email: dww_ok@uns.ac.id

Submitted: 21 January 2021; Revised: 6 November 2021; Accepted: 20 January 2022; Published: 31 January 2022

In the previous studies, decision-making in selection majors is only based on student perspective, without considering the major of the department's perspective, called the one-way approach. This approach leads to a mismatch between students' assumptions about the majors. Students may have wrong assumptions regarding the standard of competence needed in the major, the characteristics, and what is learned in the major. Therefore, this research developed TATOPSIS: a two-way approach and TOPSIS method in the DSS to help students choose a major suitable for their interests and abilities. In the two-way approach, decision-making considers the students' perspective and the majors' requirements, standards, and characteristics. Therefore, the decision results are the meeting point of perspective between students and majors. From the student way, the major becomes an alternative. On the other hand, from the major way, students become an alternative. Then, the final result is a combination of both student-way and major-way.

II. Research Methods

A. The two-way approach

The model in this research uses the two-way approach. It is considered not only from the student's perspective but also the requirements, standards, and characteristics of the majors at Sebelas Maret University. Therefore, it is necessary to calculate the positive and negative distances in both ways. The TOPSIS method is used for this problem based on its characteristics. TOPSIS has a characteristic that considers the shortest to Positive Ideal Solution (PIS) and the farthest to Negative Ideal Solution (NIS) [27]. This idea also considers the distance in two ways, from the student's perspective and the major's standard.

B. The major data

Major data collection was carried out by surveying and distributing questionnaires to the Head of Major or the Lecture of Major. There are two stages in major data collection. In the early stages, surveys related to any criteria used in this research will be conducted. Criteria obtained from the study literature then requested approval from the major lectures. Based on the result of data collection, nine criteria will be used. The criteria obtained from students' ways and majors' ways are different. These criteria are separated based on the criteria characteristics, which come from students and majors. Table 1 and Table 2 show students' and majors' criteria, respectively. Then, the next step is data collection for details of each criterion. The details of major data were obtained from lecturers from 10 majors. Table 3 lists the ten majors that become alternatives in this research.

Table 1. Student's criteria

Criteria Code	Criteria Name
C1	Grades
C2	Subjects
C3	Desired Majors
C4	Reasons for choosing major
C5	Environment

Table 2. Major's criteria

Criteria Code	Criteria Name
C6	Hard skills
C7	Soft skills
C8	Lecture Subjects
C9	Lecture Activities

Table 3. Alternatives

Major Code	Major Name
SAS	Indonesian Literature
IF	Informatics
DKV	Visual Communication Design
DI	Interior Design
EL	Electrical Engineering
MAT	Mathematics
KED	Medical
PET	Animal Science
BK	Counseling Guidance
PBIO	Biology Education

C. The two-way TOPSIS algorithm

The two-way algorithm combines the first steps of TOPSIS with an additional normalization step. The scenario is presented by considering the use of normalization. This normalization aims to manage the result both ways, considering that the results might differ. Therefore, the final result is the incorporation of the result of both ways. The two-way merging stage consists of four scenarios.

Scenario 1 and Scenario 2 are shown in Algorithm 1. Both scenarios do not use normalization. Scenario 3 and Scenario 4 are shown in Algorithm 2. Both scenarios use normalization. The final quality score is obtained with a simple linear combination. Both scores for QsA and NQsA are expressed in (1) and (2). The threshold is obtained by implementing (3) and (4) for all scenarios.

$$\mathrm{QsA} = \frac{\mathrm{QsS} + \mathrm{QsM}}{2} \tag{1}$$

$$\mathrm{NQsA} = \frac{\mathrm{NQsS} + \mathrm{NQsM}}{2} \tag{2}$$

$$T = C \times \mathrm{QsA} \tag{3}$$

$$\mathrm{NT} = C \times \mathrm{NQsA} \tag{4}$$

Let C be a constant in which the value is varied between 0 to 1. It can be customized based on the degree of confidence that needs to be gained. In this work, the C is set to 0.75. It is assumed that more significant than 0.75 is the minimum confidence of the result. The normalization is described in (5) for QsS and is also implemented for QsM in (6).

$$\mathrm{NQsS} = \frac{QsS}{QsS_{max}} \times 100\,\% \tag{5}$$

$$\mathrm{NQsM} = \frac{QsM}{QsM_{max}} \times 100\,\% \tag{6}$$

Algorithm 1. Two-way combination without normalization

Input: Major's data, student's data
Output: The set of chosen alternative (A*)
//student-way
Form the decision matrix of C1, C2, C3, C4, C5
TOPSIS computation
Obtain the quality score of the student (QsS)
//major-way
Form the decision matrix of C6, C7, C8, C9
TOPSIS computation
Obtain the quality score of major (QsM)
Calculate the final quality score (QsA)
Sort the QsA
Calculate the threshold of quality score (T)
//Scenario 1
if QsA > T **then**
    add the alternative A into the chosen set of alternative (As)
else remove alternative A
//Scenario 2
if QsS > T **and** QsM > T **then**
    add the alternative A into the chosen set of alternative (As)
else remove alternative A

Algorithm 2. Two-way combination with normalization

Input: Major's data, student's data
Output: The set of chosen alternative (A*)
//student-way
Form the decision matrix of C1, C2, C3, C4, C5
TOPSIS computation
Normalization
Obtain the normalized quality score of the student (NQsS)
//major-way
Form the decision matrix of C6, C7, C8, C9
TOPSIS computation
Normalization
Obtain the normalized quality score of major (NQsM)
Calculate the final normalized quality score (NQsA)
Sort the NQsA
Calculate the threshold of normalized quality score (NT)
//Scenario 1
if NQsA > NT **then**
    add the alternative A into the chosen set of alternative (As)
else remove alternative A
//Scenario 2
if NQsS > T **and** NQsM > T **then**
    add the alternative A into the chosen set of alternative (As)
else remove alternative A

The differences between scenarios can be seen in Table 4. These four scenarios' goal is to show variations at the merging stage and determine the consistency of the result between scenarios.

D. Dataset

Respondents to this research were high school students, prospective students, and students from Universitas Sebelas Maret. Data collection is carried out by distributing the online questionnaire. There are three classes of respondents, namely high school students (class XI and XII), prospective students (the year 2019), and students (the year 2018 and above), as shown in Table 5. These three groups of respondents were chosen to increase the feedback confidence they gave to the system. Students can already know and feel real whether the study program they have chosen is suitable or not. Then, the prospective students have completed high school level education and will choose a study program.

In contrast, students have not completed high school education but can be checked whether or not recommendations can be given. The total number of respondents from this study was 72 respondents. Sixty respondents returned agreement with the results. The distribution of respondents in this study can be seen in Table 5.

Table 4. The scenarios detail

Scenario	Quality credit score	threshold
1	Without Normalization	On the merger result
2	Without Normalization	On each way
3	With Normalization	On the merger result
4	With Normalization	On each way

Table 5. The number of respondents

Respondent	Number	Returned
High school Student (HS)	16	14
Prospective student (CS)	20	14
Student (S)	36	32

III. Results and Discussion

This section will explain the computation process and the example result using actual respondent data. There was no equal benchmark for apple-to-apple comparison with other studies. Therefore, the results of experiments compare using a common approach, which only considers one-way, to the two-way one.

The student way step is to calculate the result of the students using the TOPSIS method. Table 6 shows the result example of the calculation of students-one-way to Candidate Student no.1 (CS1).

The major way step is to calculate the result of the majors using the TOPSIS method. Table 7 shows an example of a major one-way for the department of Animal Science (PET). It is given five respondents for each category (in total of 72 data).

The two-way step is merging results from two-way, which are the way of student and way of major. Table 8 shows the main obtained values for Scenario 1 and Scenario 2. Meanwhile, Table 9 shows the main obtained values for Scenario 3 and Scenario 4.

The obtained threshold of CS1 for Scenario 1 and Scenario 2 is 0.562581. Scenario 1, based on the merger average score threshold, shows two chosen majors (IF and EL). Meanwhile, in Scenario 2, which is based on the threshold of both way's scores, there is no chosen major.

The obtained threshold of CS1 for Scenario 3 and Scenario 4 is found of 0,579475. The results are quite similar to Scenario 1 and Scenario 2. The chosen majors

Table 6. The selection result for CS1

Alternatives	C_k^* without normalization	C_k^* with normalization
SAS	0.1287	0.13478
IF	0.95495	1
DKV	0.47963	0.50226
DI	0.53267	0.5578
EL	0.51701	0.5414
MAT	0.54278	0.56839
KED	0.2188	0.22913
PET	0.20388	0.2135
BK	0.46835	0.49044
PBIO	0.1879	0.19676

Table 7. The result of PET major

Respondents	C_k^* without normalization	C_k^* with normalization
HS1	0.13220	0.15898
HS2	0.16619	0.19985
HS3	0.13220	0.15898
HS4	0.07022	0.08444
HS5	0.07022	0.08444
CS1	0.11756	0.14394
CS2	0.57423	0.70306
CS3	0.20732	0.25383
CS4	0.23123	0.28311
CS5	0.17114	0.20953
S1	0.21538	0.31330
S2	0.16707	0.24302
S3	0.26696	0.38834
S4	0.68745	1.00000
S5	0.32543	0.47338

of Scenario 3 are IF and EL. Based on Scenario 4, there is no chosen major.

C. Evaluation

The evaluation was done by calculating the compatibility level between the major's recommendation from the system and with respondent's opinion. Respondents rated Agree/Fair Agree/Disagree for each result from the one-way approach two-way approach for all scenarios. Of 72 respondents, only 60 give their opinion.

Table 10 shows that around 66,67% of respondents express positive evaluation in one-way approach. Table 11 through Table 14 show respectively the evaluation based on all scenarios (1, 2, 3, and 4) using a two-way approach.

The merger-two-way approach in Scenario 1 and Scenario 3, presented in Table 11 and Table 13, performs better positive evaluation scores compared to Scenario 2 and Scenario 4, which are based on the both-two-way approach. The merger step before normalization influences more fits distance of both values from student and major.

The result of the average approach is also better than the one-way approach. However, the one-way approach returns better results than the two-each-way approach, which does not merge before normalization (without the merger step). Therefore, the distance does not fit with the actual cases. It can be seen from the respondents

Table 8. The result of the merger-two-way for Scenario 1 and both-two-way for Scenario 2 for CS1

Alternative	Student	Major	Average
SAS	0.128705	0.19403	0.161367
IF	0.954948	0.545267	0.750108*
DKV	0.479632	0.562314	0.520973
DI	0.53267	0.431558	0.482114
EL	0.517014	0.620117	0.568565*
MAT	0.542782	0.362492	0.452637
KED	0.218804	0.274176	0.24649
PET	0.203881	0.117562	0.160721
BK	0.468348	0.45987	0.464109
PBIO	0.187897	0.387701	0.287799

Table 9. The result of the merger-two-way for Scenario 3 and both-two-way for Scenario 4 for CS1

Alternative	Student	Major	Average
SAS	0.134776	0.19403	0.164403
IF	1	0.545267	0.772634*
DKV	0.502259	0.562314	0.532287
DI	0.557799	0.431558	0.494679
EL	0.541405	0.723825	0.632615*
MAT	0.568389	0.362492	0.465441
KED	0.229127	0.274176	0.251652
PET	0.213499	0.143936	0.178717
BK	0.490444	0.45987	0.475157
PBIO	0.196761	0.532953	0.364857

Table 10. The evaluation result of the student-one-way approach

Rate	Total CS			Percentage (%)
	HS	CS	S	
Agree	8	11	21	66.67
Fair Agree	3	1	5	15
Disagree	3	2	6	18.33

Table 11. The evaluation result of the two-way approach in Scenario 1

Rate	Total CS			Percentage (%)
	HS	CS	S	
Agree	10	10	27	78.33
Fair Agree	4	2	5	18.33
Disagree	0	2	0	3.33

Table 12. The evaluation result of the two-way approach in Scenario 2

Rate	Total CS			Percentage (%)
	HS	CS	S	
Agree	6	8	23	61.67
Fair Agree	1	3	3	11.67
Disagree	7	3	6	26.67

who agree in Scenario 1 and Scenario 3 that the two-way approach is more than the one-way approach, which is 78.33% for Scenario 1 two-way approach; 73.33% for Scenario 3 a two-way approach; and 66.67% for the one-way approach. Respondents disagreed with Scenario 1 and Scenario 3 of the two-way approach is less than the one-way approach, which is 3.33% for

Table 13. The evaluation result of the two-way approach in Scenario 3

Rate	Total			Percentage (%)
	HS	CS	S	
Agree	10	10	24	73.33
Fair Agree	3	3	8	23.33
Disagree	1	1	0	3.33

Table 14. The evaluation result of the two-way approach in Scenario 4

Rate	Total			Percentage (%)
	HS	CS	S	
Agree	9	7	20	60
Fair Agree	1	3	6	16.67
Disagree	4	4	6	23.33

Scenario 1 (two-way approach); 3.33% for Scenario 3 (two-way approach); and 18.33% for the one-way approach.

Based on the results, the previous approach [10], [12], [14], [16] to choosing a major in a university, especially in Indonesia, represented as the one-way approach, needs to be improved by considering the values from the department. Therefore, the proposed two-way approach in this work can be a better way to choose the fittest major in a university. Furthermore, the same major in different universities could have different requirements. This issue makes the two-way approach will be more promising in the future.

IV. Conclusion

The best approach for selecting majors using TOPSIS is the two-way one that merges both values from student and major, as shown in Scenario 1 (accuracy 78.33%) and Scenario 3 (accuracy 73.33%). The one-way approach has an accuracy of 66.67%, and the Two-way approach without merge or each way approach in Scenario 2 has an accuracy of 61.67%, and Scenario 3 of 60%. The TOPSIS with a merger-two-way approach is preferred over the other approach.

There are still limitations of this research. Among them are the limited data of majors and students. The other limitation is that this work does not use the talent or interest test that has been standardized. Then, there is no confidence level in any recommendation given by the system. Furthermore, there are constraints in determining the correct merging method of the result from a two-way besides the average of both ways. It also missed the experiment based on major one-way. Those limitations will be considered in future work.

Acknowledgment

We thank the Research Center of Sebelas Maret University and the PNBP Grant, which support our research.

References

[1] S. K. S. Kruck and D. L. D. Lending, "Predicting academic performance in an introductory college introductory college-level IS course," *Information Technology, Learning, and Performance Journal*, vol. 21, no. 2, pp. 9–16, 2003.

[2] L. Freedman, "The developmental disconnect in choosing a major: Why institutions should prohibit choice until second year," The Mentor: Innovative Scholarship on Academic Advising, Pennsylvania, USA, vol. 15, 2013.

[3] W. Winkel, *Psikologi pengajaran*. Jakarta: Gramedia, 1989.

[4] A. A. Nurdin and K. Zainuddin, "Psychological well-being ditinjau dari coping strategy mahasiswa salah jurusan," *B.Sc thesis*, Universitas Negeri Makassar, Makasar, Indonesia, 2018.

[5] Z. Masriah, M. N. Malay, and A. Fitriani, "Persepsi mahasiswa terhadap jurusan di perguruan tinggi dan konsep diri dengan kesesuaian minat memilih jurusan," *ANFUSINA: Journal of Psychology*, vol. 1, no. 1, pp. 61–76, 2018.

[6] A. Nurhartanto, "Edukasi pemilihan jurusan kuliah melalui metode pemetaan bakat," *Jurnal Pengabdian Kepada Masyarakat*, vol. 2, no. 1, pp. 33–39, 2021.

[7] W. Primayasa, I. Arifin, and M. Y. Baharsyah, "Pengaruh salah pilih jurusan terhadap rasa putus asa mahasiswa Teknik Informatika," *Nathiqiyyah*, vol. 3, no. 1, pp. 22–27, 2020. doi: 10.46781/nathiqiyyah.v3i1.76

[8] D. Purba, "Penyesuaian diri mahasiswa yang kuliah di jurusan yang tidak diminati," in *Seminar Nasional Psikologi*, Semarang, Indonesia, Jan. 2016, pp. 120–130.

[9] C. A. Malgwi, M. A. Howe, and P. A. Burnaby, "Influences on students' choice of college major," *Journal of Education for Business*, vol. 80, no. 5, pp. 275–282, 2005. doi: 10.3200/JOEB.80.5.275-282

[10] P. A. W. Ananta, I. M. A. Wirawan, and G. A. Pradnyana, "Pengembangan sistem pendukung keputusan pemilihan jurusan kuliah di perguruan tinggi dengan metode Dempster-Shafer (Studi kasus : bimbingan konseling SMAN 1 Seririt)," *Karmapati*, vol. 7, no. 2, pp. 66–75, 2018. doi: 10.23887/karmapati.v7i2.15274

[11] M. R. Okaviana and R. Susanto, "Sistem pendukung keputusan rekomendasi pemilihan program studi menggunakan metode multifactor evaluation process di Sma Negeri 1 Bandung," *Komputa*, vol. 3, no. 2, pp. 50–57, 2014. doi: 10.34010/komputa.v3i2.2389

[12] D. Vinsensia and Y. Utami, "Penerapan fuzzy inference system (FIS) metode Mamdani dalam pemilihan jurusan perguruan tinggi," S*inkrOn: Jurnal dan Penelitian Teknik Informatika*, vol. 2, no. 2, pp. 28–36, 2018.

[13] S. Pare, "Sistem pendukung keputusan pemilihan program studi pada perguruan tinggi," *Jurnal Teknik Mustek Anim Ha*, vol. 2, pp. 58–70, 2013.

[14] D. Khuntari and R. Ferdiana, "Teknik rekomendasi pemilihan jurusan perguruan tinggi dengan

pendekatan preferensi pengguna dan analytic hierarchy process," *Semnasteknomedia Online*, vol. 3, no. 1, pp. 25–30, 2015.
[15] R. Bahaweres, F. Budiyanto, and A. Antonyova, "AHP (analytical hierarchy process) electoral college majors in indonesia based on android mobile," *ARPN Journal of Engineering and Applied Sciences*, vol. 10, pp. 457–466, 2015.
[16] Y. S. Prabowo and A. Sunyoto, "Sistem pendukung keputusan pemilihan jurusan SNMPTN bagi siswa SMAN 7 Purworejo," in *Konferensi Nasional Sistem & Informatika*, Bali, Indonesia, Oct. 2015, pp. 180–185.
[17] A. Irawan and R. Rochmawati, "Decision support system for alternative site selection of kkn using topsis," *International Journal of Computer Applications*, vol. 150, no. 7, pp. 1–6, 2016, doi: 10.5120/ijca2016911538
[18] F. Hamzeloei and M. K. Dermany, "A TOPSIS based cluster head selection for wireless sensor network," *Procedia Computer Science*, vol. 98, pp. 8–15, 2016. doi: 10.1016/j.procs.2016.09.005
[19] O. Alptekin and N. Alptekin, "Analysis of criteria influencing contractor selection using TOPSIS method," IOP Conference Series: Materials Science and Engineering, vol. 245, 062003, 2017. doi: 10.1088/1757-899X/245/6/062003
[20] X. Li, J. You, and W. Zhao, "Impact analysis of mobile medical Apps based on AHP-TOPSIS: A case study of China," in the *5th International Conference on Mathematics and Artificial Intelligence*, Chengdu, China, Apr. 2020, pp. 214–218. doi: 10.1145/3395260.3395272
[21] F. Dianawati and W. S. Perdana, "Analytic Hierarchy Process (AHP) and TOPSIS for designing green public procurement indicator on Trans-Java toll rest area," in the *5th International Conference on Industrial and Business Engineering*, Hong Kong, Hong Kong, Sep. 2019, pp. 237–242. doi: 10.1145/3364335.3364395
[22] M. M. Ulkhaq, W. R. Wijayanti, M. S. Zain, E. Baskara, and W. Leonita, "Combining the AHP and TOPSIS to evaluate car selection," in the *2nd International Conference on High Performance Compilation, Computing and Communications*, New York, USA, Mar. 2018, pp. 112–117. doi: 10.1145/3195612.3195628
[23] R. R. Kumar and C. Kumar, "Designing an efficient methodology based on Entropy-TOPSIS for evaluating efficiency of cloud services," in *the 7th International Conference on Computer and Communication Technology*, Allahabad, India, Nov. 2017, pp. 117–122. doi: 10.1145/3154979.3154982
[24] I. Petrov, "AHP enlargement in traditional Entropy-TOPSIS approach for selecting desktop personal computers for distance learning: Decomposition of evaluation criteria in blocks with AHP for better consideration of users' needs in the MCDM process on the example of the Entropy-TOPSIS approach," in *International Conference on Computer Systems and Technologies*, Ruse, Bulgaria, Jun. 2021, pp. 61–66. doi: 10.1145/3472410.3472431
[25] W. R. Wijayanti, W. R. Dewi, F. Ardi, A. Fajri, M. M. Ulkhaq, and P. Y. Akshinta, "Combining the fuzzy AHP and TOPSIS to evaluate service quality of e-commerce website," in *the 10th International Conference on Education Technology and Computers*, Tokyo, Japan, Jun. 2018, pp. 397–402. doi: 10.1145/3290511.3290514
[26] A. Jaiswal and R. Mishra, "Cloud service selection using TOPSIS and fuzzy TOPSIS with AHP and ANP," in *the 2017 International Conference on Machine Learning and Soft Computing*, Ho Chi Minh, Vietnam, Jan. 2017, pp. 136–142. doi: 10.1145/3036290.3036312
[27] X. Zhu, F. Wang, C. Liang, J. Li, and X. Sun, "Quality credit evaluation based on TOPSIS: Evidence from air-conditioning market in China," *Procedia Computer Science*, vol. 9, pp. 1256–1262, 2012. doi: 10.1016/j.procs.2012.04.137
[28] G.-H. Tzeng and J.-J. Huang, *Multiple attribute decision making: methods and applications*. Florida USA: CRC press, 2011. doi: 10.1201/b11032
[29] D. Wardani, R. Jannah, and H. Setiadi, "Major choosing decision support system with talent interest approach using SWRL and SAW method," in *the 5th International Conference on Sustainable Information Engineering and Technology*, Malang, Indonesia, Nov. 2020, pp. 95–100. doi: 10.1145/3427423.3427445