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Sensitivity analysis of the SMARTER and MOORA methods in decision making of achieving students

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Abstract — Evaluation of student learning in Islamic boarding schools is still limited to the results of exams conducted in writing which can lead to the determination of student achievement using simple criteria, resulting in less than optimal results. In addition, the importance of selecting criteria to suit the learning characteristics of the Islamic boarding school students. This study aims to find the best method to make decisions. The method used is Rank Order Centroid (ROC) in assigning weight values to the criteria applied to the Simple Multi-Attribute Rating Technique Exploiting Ranks (SMARTER) and Multi-Objective Optimization By Ratio Analysis (MOORA) methods. This study uses 30 alternatives derived from the scores of students at the Al Ma'ruf Islamic Boarding School Kediri. The results showed the same alternative value in the first rank. The accuracy is calculated using sensitivity analysis according to the results of preference values in each method. The sensitivity analysis shows that the lowest value is obtained in the first sensitivity calculation. The sensitivity value of the SMARTER method on the first sensitivity is 0.0714. At the same time, the first sensitivity value of the MOORA method is 0.0076. So the best method is owned by the MOORA method because it has the lowest sensitivity value.

Keywords – achievement, MOORA, ROC, SMARTER, students

I. Introduction

The development of digitalization is accelerating, especially in education related to learning techniques and evaluation of digital-based student learning. The evaluation of student learning in the Islamic boarding school environment needs to be carried out, namely innovations regarding the evaluation of student learning in following the trend of technological developments. The evaluation of student learning at the Al Ma'ruf Islamic Boarding School Kediri is limited to the results of exams conducted in writing, causing the determination of student achievement to only use simple criteria, giving rise to subjective results. The paper on the characteristics of the Islamic boarding school curriculum program shows weaknesses in the Islamic boarding school curriculum, especially in administration and learning evaluation, which is carried out through simple written and oral tests [1]. As stated in [1], as a learning organization, Islamic boarding schools must be able to adapt and respond to opportunities and challenges in the development of technology and information, namely competing in the field of education services in Indonesia [2].

Previous research has been carried out, including modeling the recommendations of the best Islamic boarding school students using the Multi-Objective Optimization By Ratio Analysis (MOORA) method [3] but has not used a weighting algorithm. So, this study applies the Rank Order Centroid (ROC) weighting method. Furthermore, prediction of the success rate of student performance studies [4] uses data mining techniques that certainly require training data. In addition, it also evaluates student learning in certain fields, namely the best memorization in Munaqosah Tahfizhul Qur'an [5].

Another research on using the Simple Multi Attribute Rating Technique (SMART) method has been applied to the performance assessment of Exemplary Police Members [6]. Furthermore, using the Simple Multi-Attribute Rating Technique Exploiting Rank (SMARTER) method can handle complaints

management on customer services, for an internet connection service company. Which helps provide priority decisions for resolving complaints according to the difficulty level of the disturbance and the area of interference [7]. Even studies show that in 2014 it was known that more than 100 papers had been written over a 20-year period. Which is the Multi-Criteria Decision Support System (CDSS) was used as a decision-making tool, and one of the methods used was SMART [8]. Furthermore, an analysis of the Multi-Criteria Decision Making method shows that the SMART method is a simple method that allows for all types of weighting techniques [9].

The SMART method, first proposed by Edwards in 1970, is a simple decision-making method that was later improved due to excessive subjective decision-making in the SMART method, which is the SMARTER method [10]. Meanwhile, to provide a weighted value, it is known that a multi-criteria decision analysis shows that the weighting that applies ROC has the best performance [11].

The priority level of the criteria becomes a reference in assigning a weight value. This level is what is applied in the weighting of ROC [12]. The formula for weighting W with K criteria is as follows:

$$\begin{aligned} &W_1 \geq W_2 \geq W_3 \geq \cdots \geq W_k \\ &W_1 = \frac{\left(1+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{k}\right)}{k} \\ &W_2 = \frac{\left(0+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{k}\right)}{k} \\ &W_3 = \frac{\left(0+0+\frac{1}{3}+\cdots+\frac{1}{k}\right)}{k} \end{aligned} \tag{1}$$

So the k criteria have the following weights:

$$W_k = \left(\frac{1}{k}\right)\sum_{i=k}^{K}\frac{1}{i} \tag{2}$$

with W is criteria weighting value, k is number of criteria, and i is an alternative value. Next, (3) is calculation of the utility value.

$$v\left(x\right) = \sum_{i=1}^{n} w_i v_i\left(x\right). \tag{3}$$

with w_i is the weight that affects the i-th dimension on the overall value of the evaluation. Meanwhile, v_i is the evaluation object on the i-th dimension, and n is number of different value dimensions. The formula for calculating the final value is shown in (4).

$$n_i = \sum_{j=1}^{k} n w_j u_{ij} \tag{4}$$

with w_j is the weight of the 1st criterion, u_{ij} is utility value of the $-j$ criteria for the i-th family, and n_i is an alternative final score.

A paper shows the best way to get the ranking of criteria into weights is based on the number of criteria. The distribution of weights, which is following the results of a comparison of five methods, namely Rank-Sum Weights (RS), Reciprocal Rank weights (RR), ROC weights, Weights Geometric (GW), and Variable-Slope Linear (VSL). However, about the probability distribution, ROC is the best method in exponential weighting [13].

The use of ROC has been applied to score areas that have the potential to develop renewable energy made from palm oil waste [14], and its measurement uses multi-criteria decision-making sensitivity analysis [15].

The MOORA method is obtained from the multiplication of the attribute ratings. The attribute rating is raised to the first power with the weight of each column. The Preference Value is aimed at the Si alternative. The order of the MOORA method includes [16]:

A. Determination of the Value of the Decision Matrix

The next step is determining the objectives in identifying the evaluation attributes in question.

$$X = \begin{bmatrix} x_{i1} & x_{i2} & \cdots & x_{1n} \\ x_{j1} & x_{j2} & \cdots & x_{jn} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{5}$$

with x_{ij} is the alternative response j on criterion i, where i = 1, 2, 3, $\cdots$, n is the sequence number of the attribute or criterion, and j = 1, 2, 3, $\cdots$, m is alternative sequence number. Meanwhile, X is the decision matrix.

B. Matrix Normalization

The denominator comes from the square root of the sum of the squares and each alternative for each attribute [17].

$$X_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \tag{6}$$

with x_{ij} is an alternative matrix j on criterion i, where i = 1, 2, 3, $\cdots$, n is the sequence number of the attribute or criterion, and j = 1, 2, 3, $\cdots$, m is alternative sequence number. Meanwhile, X_{ij}^{*} is the alternative normalization matrix j on criterion i.

C. Optimizing Attributes

In multi-objective optimization, profitable attributes, can be added during normalization. On the other hand, unfavorable attributes can be reduced.

$$Y_j = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^*. \quad (7)$$

with i = 1, 2, 3, $\cdots$, g, is an attribute or criterion with maximized state. Meanwhile, $j = g+1$, $g+2$, $g+3$, $\cdots$, n, is an attribute or criterion with minimized state. Finally, Y is an alternate max-min normalization matrix j.

Variable g is the number of maximized attributes, while $n-g$ is the number of minimized attributes. Y_i is the value that has been normalized from the first alternative to all attributes (as shown in (8)).

$$Y_i = \sum_{j=1}^{g} w_j x_{ij}^* - \sum_{j=g+1}^{n} w_j w_{ij}^* \quad (8)$$

where i = 1, 2, 3, $\cdots$, g, is an attribute or criterion with maximized state. Meanwhile, $j = g+1$, $g+2$, $g+3$,$\cdots$, n is an attribute or criterion with minimized state. Finally, w_j and y are weight against alternative j, and the normalized value of the alternative j, respectively.

D. Y_i Rating Ranking

The Y_i value can be positive or negative based on the decision matrix's maximum and minimum total values. In ranking order, then Y_i shows the last choice. So it is known that the best alternative is Y_i with the highest value, while the worst alternative is the lowest Y_i value.

The results of this study are useful for Islamic boarding schools in making decisions for outstanding students. The combination of the MOORA method and ROC weighting is known to be better based on a lower sensitivity value than the SMARTER method. So, this research can be used to make decisions for outstanding students in a particular field or at other educational institutions.

II. Research Method

A. Research Steps

The steps of this research consist of conducting a literature review, collecting research data, using ROC weighting, applying ROC weighting in the SMARTER and MOORA methods, and conducting sensitivity analysis between the two methods. The research steps are shown in the flow chart according to Fig. 1.

B. Literature Review

Literature study is an activity to collect references from trusted sources, namely electronic scientific articles from international and national journals, books, and electronic articles, to get the theory needed.

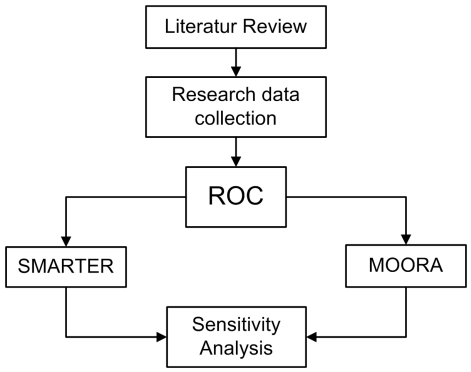

Fig. 1. Research flowchart.

C. Research Data Collection

The research data used came from the Al Ma'ruf Islamic Boarding School Kediri. The criteria data and the priority order, include kitab kuning reading skills (grammatics), morals, written examination, muhafadzoh, thamrin, attendance, and book correction. Data collection for students is carried out at each grade level. So the results of the calculation show that students excel at that class level.

D. Assessment Criteria, and Priorities

The following is an explanation of the criteria, the value of each sub-criteria, and the order of priority. An explanation of the criteria used in this study is shown in Table 1.

Table 1. List of Criteria in this Study

Code	Criteria Name	Order of Priority
C1	Kitab kuning reading skills (Grammatics)	1
C2	Morals	2
C3	Written examination	3
C4	Muhafadzoh	4
C5	Thamrin	5
C6	Attendance	6
C7	Kitab correction	7

The value of the C1 criteria is shown in Table 2. Meanwhile, the value of C2 criteria obtained from the sub-criteria by the Islamic boarding school characteristics and provisions is shown in Table 3 and Table 4.

Table 2. The Value of the Criteria C1

Data Entry	Skills	Test Scores
Very fluent	Students can read correctly and interpret well	10
Fluent	students can read correctly and interpret less accurately and or vice versa	8
Quite fluent	Students are less able to read the kitab kuning and misinterpret it	6
Less fluent	students cannot read and interpret the kitab kuning	4
Not present	students are not current in the kitab kuning reading exam	1

The value of the C3 criteria is the value of the test results obtained from the implementation of the final

Table 3. The value of Sub Criteria from Criterion C3

No.	Name of Sub Criteria
1	Students wear white clothes on Wednesdays and Saturdays.
2	Students wear the national standard black letterhead.
3	Students participate in deliberations before teaching and learning activities begin.
4	Students follow Lalaran (communal repetition of memorizing activities) before teaching and learning activities begin.

Table 4. Values of Criterion C3 Based on Sub Criteria

Data Entry	Provision	Scores
Very good	Students carry out all sub-criteria activities.	10
Good	Students carry out three sub-criteria activities.	8
Pretty good	Students carry out two sub-criteria activities.	6
Not good	Students only do one activity and don't even carry out activities.	4

exam, and C5, namely Thamrin, is the midterm exam. The value of the two criteria is taken from the average important value taken by each student. The C3 and C5 criteria values are shown in Table 5.

Table 5. Values of Criteria C3 and C5

Value of Answers Derived from 10 Questions	Scores	Description
The value given is according to the correct answer of 10 questions	8-10 6-7 4-5 0-3	Very good Good Pretty good Not good

The value of the C4 criteria is obtained from the implementation of the book, not good memorization exam (Muhafadzoh), which was determined at the beginning of the grade promotion. Therefore, the value of the C4 criteria is shown in Table 6.

Table 6. Criteria Value C4

Data Entry	Muhafadzoh Exam	Scores
Very good (Jayyid Jidan)	Students can memorize all the lines.	10
Good (Jayid)	Students can memorize more than 70% of the line.	8
Pretty good (Mutawasith)	Students can memorize between 60% and 40% of lines.	6
Not good (Rodi')	Students can memorize less than 30% of lines.	4
Not present (Ghoib)	Students are not present in the examination.	1

The value of the C6 criteria is shown in Table 7. The value of the C7 criteria comes from the number of lessons a student takes. The requirement for obtaining a perfect assessment (tam) is that none of the lessons (books) are defective (naqish). The assessment of book corrections is shown in Table 8.

E. ROC Weighting

The weighting of the criteria uses the ROC algorithm in order of priority. The value of the weighting criteria using the ROC is shown in Table 9.

Table 7. Values of Criterion C6

Data Entry	Attendance of a Student in One Semester	Description
student attendance recapitulation	More than 80% Between 60% - 70% Between 40% - 50% Less than 30%	Very good Good Pretty good Not good

Table 8. Values of Criterion C7

Data Entry	Description	Scores
Perfect	All books are full of pegon meanings (modification of Arabic letters to write Javanese).	5
Defect value	Not all books are full of Pegon meanings, even though it is only one book.	3
Not present	Not present at the examination.	1

III. RESULT

A. Implementation of the SMARTER Method

Based on the final value of the calculation using the SMARTER method, namely the total utility value for each alternative, the highest value indicates the first rank owned by the 4th alternative (A4). The utility value for each student is shown in Table 10.

B. Implementation of the MOORA Method

The application of the MOORA method produces a ranking for each alternative. The ranking results are shown in Table 11. The 4th alternative indicates the highest value.

Based on the ranking results from the SMARTER and MOORA methods, it is known that the fourth alternative data has the highest value. The SMARTER method for the highest score of A4 is 2.143. At the same time, the highest alternative MOORA value method owned by A4 with total value 0.229.

IV. DISCUSSION

Sensitivity analysis was performed to measure the ranking results. Measurements are carried out by subtracting the final value of the first alternative and the second alternative, dividing the value of the first alternative by the total number of available alternative values, and dividing by two the sum of the results of the first alternative and the second alternative [15].

Based on the sensitivity comparison between the SMARTER and MOORA methods that apply ROC weighting in Table 12, the first, second, and third sensitivity values have been obtained. The first sensitivity value for the SMARTER method is 0.0714,

Table 9. ROC Weighting

No.	Criteria	Priority	Weight
1	Kitab kuning reading skills	1	0.370408
2	Morals	2	0.227551
3	Written examination	3	0.156122
4	Muhafadzoh	4	0.108503
5	Thamrin	5	0.072789
6	Attendance	6	0.187075
7	Kitab correction	7	0.020408

Table 10. Ranking Results of the SMARTER Method

Alternative	Total Value	Rating
A4	2.143608844	1
A12	0.579914116	2
A2	0.561716837	3
A5	0.504829082	4
A26	0.504829082	5
A17	0.483128401	6
A10	0.477431122	7
A11	0.477431122	8
A3	0.466580782	9
A9	0.463179422	10
A7	0.448987245	11
A14	0.448987245	12
A15	0.448987245	13
A18	0.448987245	14
A24	0.448987245	15
A25	0.448987245	16
A28	0.448987245	17
A8	0.445585884	18
A21	0.445585884	19
A22	0.445585884	20
A29	0.445585884	21
A6	0.442921485	22
A13	0.438136905	23
A19	0.434735544	24
A27	0.434735544	25
A23	0.43002466	26
A16	0.356385204	27
A20	0.352983844	28
A30	0.254188492	29
A1	0.19164881	30

Table 11. Ranking Results of the MOORA Method

Alternative	Total Value	Rating
A4	0.229524	1
A6	0.228799	2
A24	0.227596	3
A23	0.222847	4
A13	0.221364	5
A18	0.216598	6
A2	0.213372	7
A16	0.21253	8
A12	0.210958	9
A26	0.209587	10
A10	0.204142	11
A5	0.203663	12
A3	0.200898	13
A15	0.199304	14
A29	0.197828	15
A9	0.197114	16
A28	0.194645	17
A8	0.193152	18
A11	0.192861	19
A14	0.192789	20
A17	0.191507	21
A20	0.19042	22
A27	0.189828	23
A19	0.187689	24
A7	0.184586	25
A25	0.184328	26
A22	0.180995	27
A21	0.169342	28
A1	0.165905	29
A30	0.164736	30

Table 12. Sensitivity Comparison

Sensitivity	SMARTER	MOORA
Sensitivity 1	0.0714	0.0076
Sensitivity 2	0.0334	0.0334
Sensitivity 3	0.4617	0.1954

while the MOORA method is 0.0076. The same result is obtained for the second sensitivity value for the SMARTER and MOORA, for 0.0334. Furthermore, the third sensitivity value for the SMARTER method is 0.4617, while the MOORA method is 0.1954. Therefore, the results of the sensitivity analysis in this study indicate that the best method is the MOORA method which has the lowest value in the calculation of the first sensitivity value.

V. Conclusion

Applying the ROC weighting algorithm in the SMARTER and MOORA methods has resulted in the best alternative ranking that shows students' achievement. The results of the first rank of alternative students are shown on the same alternative that comes from the calculation of the two methods. Based on the calculation of the sensitivity value, it can be concluded that the best method is MOORA because it meets the lowest sensitivity value. This research is still limited to data analysis. In the future, it can be developed by building intelligent applications that can be applied to several platforms such as web-based and mobile. And can be developed more widely by applying other multi-criteria decision-making methods.

References

[1] A. Prayoga, "Karakteristik program kurikulum pondok pesantren," *J. AL-HIKMAH*, vol. 2, no. 1, pp. 77–86, 2020.

[2] M. Ghafar, "Pesantren of learning organization: analisis transformasi pengembangan pondok pesantren di indonesia," in *Proc. Annu. Conf. Muslim Sch.*, no. Seri 2, pp. 777–784, 2017.

[3] I. N. Farida, R. Firliana, and R. K. Niswatin, "Pemodelan rekomendasi santri terbaik menggunakan multi-objective optimization by ratio analysis," *J. Teknol. dan Ris. Terap.*, vol. 1, no. 2, pp. 66–71, 2019.

[4] A. A. A. Miftachuddin, Kusrini, and E. T. Luthfi, "Prediksi tingkat keberhasilan studi kinerja santri menggunakan algoritma c 5.0," *Saintekbu*, vol. 12, no. 2. pp. 45–57, 2020.

[5] D. Indriani and A. I. Warnilah, "Sistem informasi hafalan terbaik dalam munaqosah tahfizhul qur'an menggunakan metode ahp," *EVOLUSI - J. Sains dan Manaj.*, vol. 7, no. 1, pp. 1–11, 2019.

[6] Sriwahyuni, "Sistem penilaian kinerja anggota kepolisian teladan menggunakan metode simple multi attribute rating technique (SMART) (studi kasus di polsek sngingi hilir," *J. Perencanaan. Sains, Teknol. dan Komput.*, vol. 3, no. 1, pp. 163–175, 2020.

[7] W. Setiyaningsih, "Sistem pendukung keputusan manajemen komplain menggunakan metode simple multi-attribute rating technique exploiting rank," *J. Teknol. Inf. dan Terap.*, vol. 1, no. 2, pp. 95–102, 2014.

[8] J. Razmak and B. Aouni, "Decision support system and multi-criteria decision aid: A state of the art and perspectives," *J. Multi-Criteria Decis. Anal.*, vol. 22, no. 1–2, pp. 101–117, 2014.

[9] M. Velasquez and P. T. Hester, "An analysis of multi-criteria decision making methods," *Int. J. Oper. Res.*, vol. 10, no. 2, pp. 56–66, 2013.

[10] Y. Li and Z. Hu, "A review of multi-attributes decision-making models for offshore oil and gas facilities decommissioning," *J. Ocean Eng. Sci.*, 2021.

[11] P. Kunsch and V. U. Brussel, "A critical analysis on rank order centroid (roc) and rank sum weights in multicriteria decision analysis," *Vrije Univ. Brussel*, no. June, 2019.

[12] F. H. Barron and B. E. Barrett, "The efficacy of smarter - simple multi-attribute rating technique extended to ranking," *Acta Psychol. (Amst).*, vol. 93, no. 1–3, pp. 23–36, 1996.

[13] H. K. Alfares and S. O. Duffuaa, "Simulation-based evaluation of criteria rank-weighting methods in multi-criteria decision-making," *Int. J. Inf. Technol. Decis. Mak.*, vol. 15, no. 1, pp. 43–61, 2016.

[14] P. H. Noprita, R. Annisa, and S. T. Rizaldi, "Penerapan algoritma smarter-roc untuk scoring wilayah potensial pengembangan energi terbarukan dari Limbah Kelapa Sawit," in *Semin. Nas. Teknol. Informasi, Komun. dan Ind. 11*, November, pp. 64–70, 2019.

[15] M. Kusmiyanti, Richa Dwi, Suliatun, "Analisis sensitifitas model smart-amp dengan smarter-roc sebagai pengambilan keputusan multi kriteria," in *Semin. Nas. Teknol. Informasi, Komun. dan Ind. 9*, pp. 18–19, 2017.

[16] N. W. Al-Hafiz, Mesran, and Suginam, "Sistem pendukung keputusan Penentukan Kredit pemilikan rumah menerapkan multi-objective optimization on the basis of ratio analysis (moora)," *KOMIK (Konferensi Nas. Teknol. Inf. dan Komputer)*, vol. 1, no. 1, pp. 306–309, 2017.

[17] W. K. M. Brauers, E. K. Zavadskas, F. Peldschus, and Z. Turskis, "Multi-objective decision-making for road design," *Transport*, vol. 23, no. 3, pp. 183–193, 2008.