Scientific Journal of Informatics
Vol. 11, No. 4, Nov 2024

p-ISSN 2407-7658 https://journal.unnes.ac.id/journals/sji/index e-ISSN 2460-0040

Determining Lecturers' Research Linearity Using Simple Additive Weighting and Technique for Order Preference by Similarity to Ideal Solution

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Abstract.
Purpose: This study aims to conduct a comparative analysis of the decision-making methods of Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and build a decision support system that can be used to determine the linearity of lecturers' research in their scientific fields. The analysis aims to assist relevant institutions in determining research linearity and guiding lecturers in their research policies and directions.
Methods: This study compares the performance of the SAW and TOPSIS methods, against the alternative ranking of lecturers' research linearity. The performance of both methods was measured using accuracy and MSE, where a high accuracy value indicates that the method performs better and the value of MSE is small or close to zero indicating a better relevance.
Result: The results showed that the SAW method has a better accuracy value of 100% and an average MSE value of 0.13. At the same time, the TOPSIS method has an accuracy value of 33% and an average MSE value of 0.58.
Novelty: This study provides knowledge about the effectiveness and efficiency of decision-making methods to determine the lecturers' research linearity, as a guideline for related institutions regarding research policy making. In addition, the results of this study also provide a framework for evaluating the recent decision-supporting method and improving the understanding of the implementation and performance of the methods.

Keywords: Decision support system, Multiple criteria decision making, Simple additive weighting, Technique for order preference by similarity to ideal solution, Mean square error
Received September 2024 / **Revised** January 2025 / **Accepted** February 2025

INTRODUCTION

One of the objectives of the Republic of Indonesia as stated in the Preamble of the 1945 Constitution is to enhance national education. The government strives to achieve this goal through the implementation of education from primary to higher education [1]. The highest level that plays a crucial role in achieving these goals is higher education [1]. One of the most important elements of higher education is lecturers. According to Law Number 14 of 2005 on teachers and lecturers, lecturers are professional educators and scientists with the main task of transforming, developing, and disseminating science, technology, and art through education, research, and community service [2]. From this definition, the work undertaken by lecturers is known as *Tridharma Perguruan Tinggi* (Three Pillars of Higher Education)[3]. The success of higher education cannot be separated from the role of lecturers who conduct the *Tridharma* [4]. In the education implementation, research conducted in the form of scientific publications plays an important role in the scientific development and the education quality. Therefore, lecturers play an important part as the role model for the implementation of higher education [4].

The research results have a big role in the *Tridharma* of Higher Education, both for the functional career of lecturers and in improving the accreditation rank of study programs and institutions [5]. Research result achievement is one of the main indicators in improve universities' rank, both at national and international levels [6]. There are some researches showing that lecturers' motivation in conducting research is dominated by the obligation to report *Beban Kinerja Dosen* (BKD) which causes some lecturers to only include their names [7] and many researches were done carelessly [8]. Researches that are not based on the lecturers' scientific field and tend to be just formality have less impact and are appreciated by the

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DOI: 10.15294/sji.v11i4.14024

community, particularly the scientific community, this problem also affects lecturers' careers and they will find difficulties in integrating their research results in their classes [9].

It is very important to provide research guidelines for lecturers and encourage them to carry out research and publications according to their expertise [10]. This effort therefore needs to be implemented in order to fulfil the data required for accreditation and help students find ideas for their research faster [11]. According to the regulation of the Minister of Education and Culture of the Republic of Indonesia Number 3 of 2020 on the National Standard for Higher Education Article 50, lecturers must have the ability to master the level of research methodology in specific scientific fields. In universities, there is an institution in charge of managing all research and community service activities carried out by lecturers, namely the *Lembaga Penelitian dan Pengabdian Masyarakat* (LPPM) [12]. Some of LPPM's tasks are directing, fostering, and improving the lecturers' research skills in their scientific fields based on their expertise, and it is necessary to provide this institution with a tool that can help determine the linearity of lecturer research in their scientific fields.

Based on the aforementioned problem, this research aims to develop a Decision Support System (DSS) that can be used to determine the linearity of lecturers' research with their respective fields of study. This will enable both lecturers and the Research and Development Institute to ascertain whether the conducted research aligns with lecturers' areas of expertise. The DSS to be constructed will employ the Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. TOPSIS promotes options that are closest to the positive ideal solution and furthest from the negative ideal solution, whereas the SAW technique depends on computing the weighted total of performance scores for each option across all criteria. Several studies have utilized the SAW and TOPSIS methods, including the research conducted by Bachchhav et al. (2023) on the selection of welding electrode materials using AHP, TOPSIS, and SAW [13] and a research by Chakraborty and Subrata (2022) who analyzed the comparison of TOPSIS and its modifications [14]. Furthermore, there is research on the comparison of oxygen production techniques using TOPSIS, MEW, and SAW [15].

Previous research related to the linearity of faculty research, conducted by Renkema dan Tursunbayeva (2024), suggested the need to develop a research roadmap relevant to the lectures's field of study [9]. Research by Chowdhury, P. (2024) indicated that many of faculty members still conduct research outside their field [16]. Wube et al. (2024) also mentioned that some faculty members conduct research not based on their academic background but according to their passion [17]. Therefore, as professional development, there is a need for motivation for these lecturers to develop their skill [18]. In the aforementioned previous studies, however, the solutions offered were theoretical.

The proposed solution in this research is a practical approach involving the use of a method to determine the linearity of lecturers' research. This method will be implemented in a decision support system with parameters including their fields of study, courses taught, research history, and graduate program profiles. This structured approach provides decision-makers with a transparent framework for evaluating alternatives [19]. Decision support systems are widely used in various fields, such as healthcare, industry, law, and others [20]. Some common aspects of decision support systems include computer-based systems designed for interactive use by decision-makers; support decision-making at various levels within an organization that guide the organization towards the best solution; and serve as independent business systems or subsystems of larger, integrated information systems [21].

The development of a Decision Support System in this research proposal uses SAW and TOPSIS methods. When it comes to Multi-Criteria Decision Making (MCDM), the SAW method is the most popular and simple technique. The rating results of the SAW method are not much different from real-world practice, in addition, the output is comprehensive for decision makers compared to similar approaches [22][23]. TOPSIS is an MCDM technique that can be applied in a continuous scenario for a wide spectrum of research. Its ease and sustainability in producing hybrid MCDM models for Decision Support makes this method widely used. In addition, TOPSIS is one of the main MCDM techniques used to evaluate sustainability in information and computer technology projects [24]. As research conducted by Jovanovic et al., (2016) using the TOPSIS method to develop a methodology that will compare their relevant performance [25].

In this study, several tests were carried out, namely, testing of alternative rankings produced by SAW and TOPSIS methods using accuracy calculations [23], and testing the predictive error rate of both methods using the calculation of Mean Square Error (MSE) [26]. While testing the system's functionality, use black box testing based on equivalent partitions testing to determine whether there are errors in the system's interface, structure or data access, performance, and initialization [27][28][29].

METHODS

This study employed the SAW and TOPSIS methodologies to develop a decision support system for evaluating the alignment of faculty research with their fields of study. Both methods were used to calculate the ordering of options. In order to choose the best option throughout the decision-making process, the SAW approach is recommended in this study. Through mathematical calculations, the SAW technique generates a weighted sum of performance scores for every criterion [30]. The selection of the SAW method is based on its advantage in assigning weights to each criterion. After obtaining the weights for each criterion, a ranking is then performed to determine the best alternative in the decision-making process [31]. According to the TOPSIS technique, the option that is selected should be the one that is most similar to the positive ideal solution and the one that is most dissimilar from the negative ideal solution [32]. By considering the distance between each alternative and the positive and negative ideal solutions, the TOPSIS technique offers a more comprehensive approach. TOPSIS provides a clearer picture of each alternative's relative place in the decision-making process [33].

The method of system development used in this study is the System Development Life Cycle (SDLC) using the waterfall model. This paradigm describes a methodical and disciplined approach to software development. The stages of the waterfall model are shown in Figure 1.

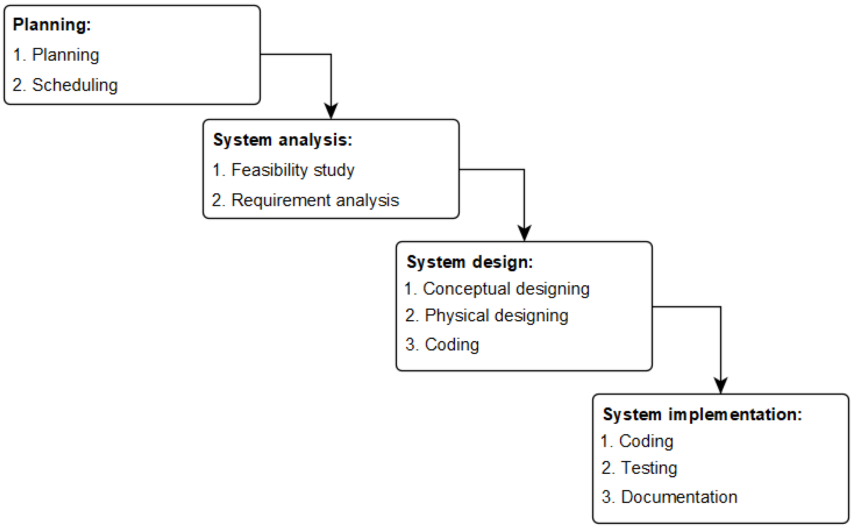

Figure 1. Stages waterfall model [34]

There are four stages in the development of this system. The first stage is planning. In this planning phase, the research team analyzed the problems and planned a reasonable solution to resolve these problems. The problems were related to determining the linearity of lecturers' research with their scientific fields. The research team agreed to provide a solution in the form of Decision Support System Development as a practical solution. In this planning phase, collaboration is needed between the research team as a developer and user which in this case is LPPM and each stage in the development of the system were discussed between both parties. The targeted outcome is the establishment of a comprehensive work control system that outlines all tasks involved and their respective timelines.

The second stage is system analysis. In this stage, a feasibility study was conducted before building the new system to determine the effectiveness of proposed solution. The process was the determination of problems and opportunities aimed at the system, the formation of overall system objectives, user identification, the formation of the scope of the system, the proposal of software (software) and hardware (hardware) needed, as well as cost or benefit analysis of the new system. The analysis of system requirements was conducted after the feasibility study. The stage of need analysis of this system involves the user of the system. In this research, interview and observation of potential users were carried out to understand their needs for the system. Studying the existing systems and solutions to similar problems. The goal was to identify the specific information and data needed for the system, such as the criteria for the SAW and TOPSIS methods, weighting factors, and details about lecturers' research. Other targeted achievement indicators include the definition of output requirements, such as information on the ranking of alternatives that can be used by the LPPM or LP2M to determine the linearity of faculty research. Process requirements, encompassing the necessary processes to generate the defined output, must also be determined. Software requirements, such as operating systems and other necessary application software for system development, are needed. The final targeted achievement indicator for the system analysis phase is the definition of hardware requirements, including the need for RAM, hard disk, and other components based on the requirements of the system to be built.

In designing the system, the third stage was made to meet the needs of users during the analysis phase. At the conceptual design stage, the research team prepared design specifications and conceptual system design reports. Achievement indicators targeted at the conceptual design stage are the formation of use case diagrams, activity diagrams, class diagrams, and sequence diagrams. While at the physical design stage, achievement indicators were targeted in the form of input, output, interface, database, and documentation designs as well as test plans.

The fourth or last stage is the system implementation stage, which is the programming process (coding) followed by a testing process involving users and other external parties, installing software and hardware required by the system, training for the user, and making documentation. The achievement indicators targeted at the implementation stage are the development of a decision support system that can be applied by the user and the documentation of system development, operation, and use.

Simple additive weighting (SAW)

The basic concept of this method is to find a weighted summation of the performance rating on each alternative on all criteria [35]. SAW method steps:

1. Recognizing the standards that serve as guidelines for the decision-making process (C_i).
2. Evaluate each alternative's compatibility rating according to each criterion.
3. Developing a decision matrix according to the standards, followed by normalizing the matrix using an equation tailored to the criterion type (benefit or cost), resulting in a normalized matrix.
4. After the normalized matrix multiplications R are added up using the weight vector, the best option (A_i) is chosen as the solution. This is the end result of the ranking procedure. The equation for normalizing is:

$$R_{ij} = \left\{\begin{matrix} \dfrac{x_{ij}}{Max_{ij}} \\ \dfrac{Min_{ij}}{x_{ij}} \end{matrix}\right\} \tag{1}$$

Description:

R_{ij}	:	Normalized performance Rating
Max_{ij}	:	Greatest value in every column and row
Min_{ij}	:	Lowest values in every column and row
x_{ij}	:	Columns and rows of a matrix

With R_{ij} is the normalized performance rating of the alternative A_i on the criteria C_i, where i = 1, 2,..., m and j = 1, 2,..., n. The equation calculates the preference value for each alternative (V) is:

$$V_i = \sum_{j=1}^{n} W_j \times R_{ij} \tag{2}$$

Description:

V_i	:	Value of the alternative in the end
W_j	:	Determine the weights

R_{ij} : Normalization of a matrix

When V is higher, it means that alternative A_i is chosen.

Technique for order of preference by similarity to ideal solution (TOPSIS)

The TOPSIS method uses the principle that the chosen alternative must have the shortest distance from the positive ideal solution and have the farthest distance from the negative ideal solution from a geometric point using Euclidean distance to determine the relative proximity between the alternatives to the optimal solution [36]. Stages of the TOPSIS approach:

1. Create the normalized decision matrix

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}} \tag{3}$$

2. Normalization of weight

With weights $w_j = (w_1, w_2, w_3, \ldots, w_n)$ where w_j is the criterion weight for all j and $\sum = 1 = 1$, normalizing Matrix weights V, where:

$$V_{ij} = w_j \times r_{ij} \tag{4}$$

3. Determining the matrix of positive ideal solutions and negative ideal solutions

$$\begin{aligned} A^+ &= \{(\max v_{ij} | j \in J), (\min v_{ij} | j \in J'), i = 1, 2, 3, \ldots, m\} \\ A^+ &= \{(V1^+, V2^+, V3^+, \ldots, Vn^+)\} \\ A^+ &= \{(\min v_{ij} | j \in J), (\max v_{ij} | j \in J'), i = 1, 2, 3, \ldots, m\} \\ A^+ &= \{(V1^-, V2^-, V3^-, \ldots, Vn^-)\} \end{aligned} \tag{5}$$

4. Finding the distance
   a. The following definition S^+ is the alternative's separation from the positive ideal solution:

$$S_i^+ = \sqrt{\sum_{j=i}^{n} (V_{ij} - V_i^+)} \tag{6}$$

   where $i = 1, 2, 3, \ldots, m$

   b. The following definition S^- is is the alternative's separation from the negative ideal solution:

$$S_i^- = \sqrt{\sum_{j=i}^{n} (V_{ij} - V_i^-)} \tag{7}$$

   where $i = 1, 2, 3, \ldots, m$

5. Figuring out each alternative's preferred value

$$C_i^+ = \frac{S_i^+}{(S_i^+ + S_i^-)} \tag{8}$$

6. Alternative Ranking

   From highest to lowest value, alternative C^+ is arranged. It is thought that the best option is the one with the highest C^+ rating.

RESULTS AND DISCUSSIONS

In this study, the weight of the criteria has been determined. The linearity is evaluated according to each method's steps, taking into account their academic subject. The criteria used are lecturers ' field of knowledge, courses taught, research history, and graduate profiles of study programs. Alternative Data are shown in the following table 1:

Table 1. Alternative Data

No.	Alternative	C1	C2	C3	C4
1	A1	0.2	0.06	0.3	0.25
2	A2	0.07	0.06	0.3	0.25
3	A3	0.3	0.06	0.3	0.25

Calculation using the SAW method:

1. Determining which criteria will serve as a guide for the decision-making process

Table 2. Criteria

Criteria	Weight (W_j)
C1	0.40
C2	0.30
C3	0.10
C4	0.20

2. Using each criterion to evaluate each alternative's compatibility grade

$$R_{ij} = \begin{bmatrix} 0,667 & 1,000 & 1,000 & 1,000 \\ 0,233 & 1,000 & 1,000 & 1,000 \\ 1,000 & 1,000 & 1,000 & 1,000 \end{bmatrix}$$

3. Building a decision matrix according to the criteria and normalizing it with formulas tailored to the kind of criterion (cost or profit) to produce a normalized matrix

Table 3. Preference Weight Values

V_i	Value
V_1	0.867
V_2	0.693
V_3	1.000

4. The ranking process determines the ultimate result

Table 4. Preference Weight Ranking

Ranking	V_i	Value	Alternatives
1	V_3	1.000	A3
2	V_2	0.867	A1
3	V_2	0.693	A2

The SAW method's computation results showed that option A3, with a preference weight of 1.000, was ranked highest, followed by options A1 and A2.

The TOPSIS method calculation:

1. Create a normalized decision matrix

$$R_{ij} = \begin{bmatrix} 0,545 & 0,577 & 0,577 & 0,577 \\ 0,191 & 0,577 & 0,577 & 0,577 \\ 0,817 & 0,577 & 0,577 & 0,577 \end{bmatrix}$$

2. Normalization of weight

$$R_{ij} = \begin{bmatrix} 0,218 & 0,173 & 0,058 & 0,115 \\ 0,076 & 0,173 & 0,058 & 0,115 \\ 0,327 & 0,173 & 0,058 & 0,115 \end{bmatrix}$$

3. Figuring out the matrix of optimal solutions, both positive and negative

Table 5. Positive Ideal Solution

Y_i^+	Values
Y_1^+	0.327
Y_2^+	0.173
Y_3^+	0.058
Y_4^+	0.115

Table 6. Negative Ideal Solution

Y_i^-	Values
Y_1^-	0.076
Y_2^-	0.173
Y_3^-	0.058
Y_4^-	0.115

4. Finding the distance
   a. The following definition S^+ is the alternative's separation from the positive ideal solution:

Table 7. Positive Ideal Solution Distance

S_i^+	Values
S_1^+	0.109
S_2^+	0.250
S_3^+	0.000

   b. The following definition S^- is is the alternative's separation from the negative ideal solution:

Table 8. Negative Ideal Solution Distance

S_i^-	Values
S_1^-	0.142
S_2^-	0.000
S_3^-	0.250

5. Figuring out each alternative's preferred value

Table 9. Preference Values

C_i	Values
C_1	0.435
C_2	1.000
C_3	0.000

6. Alternative Ranking

Table 10. Preference Value Ranking

Ranking	C_i	Values	Alternatives
1	C_2	1.000	A2
2	C_1	0.435	A1
3	C_3	0.000	A3

Alternative A2, with a preference value of 1.000, was ranked top, followed by alternatives A1 and A3, according to the TOPSIS technique calculation results.

The evaluation of the two methods used in this study applies the calculation of accuracy and MSE. The accuracy value can be calculated using the following equation:

$$Accuracy = \frac{number\ of\ data\ accuracy}{number\ of\ data} \times 100\% \tag{9}$$

Table 11. Accuracy Comparison

Rank	Actual	SAW	TOPSIS
1	A3	A3	A2
2	A1	A1	A1
3	A2	A2	A3

The comparison chart shows that the rankings obtained using the SAW method align perfectly with the actual rankings, confirming 100% accuracy. The TOPSIS method computation, on the other hand, reveals that only one data point is accurate, indicating a mere 33% accuracy. MSE value in this study was calculated using the following equation:

$$r_s = 1 - \frac{6\sum_{j=1}^{n} d_j^2}{n(n^2-1)} \tag{10}$$

Where:

$$d_j = x_j - y_j \tag{11}$$

and

$$m_r = \frac{1 - r_s^2}{\sqrt{n}} \tag{12}$$

Description:
r_s : Spearman Rank Correlation Coefficient
n : Number of ranking pairs
m_r : MSE of the correlation coefficient calculation

Based on the computation made using the previously given formula, the MSE value is 0.13 for the SAW method and 0.58 for the TOPSIS method. Prediction results are better if the value of the MSE is getting smaller [37]. Therefore, the SAW method has a better performance than the TOPSIS method.

The system was tested using the Black Box Testing method[38], and all system functions operated as expected. Based on user responses, respondent data showed that the decision support system in determining the linearity of lecturers' research using SAW and TOPSIS was feasible to use.

CONCLUSION

Based on the findings, the Simple Additive Weighting (SAW) method is recommended for determining the linearity of lecturers' research across multiple criteria and alternatives, as it outperforms the TOPSIS method. Future research should investigate various decision support system methods, including the Weighted Product Method (WP), Multi-Objective Optimization based on Ratio Analysis (MOORA Method), a New Additive Ratio Assessment(ARAS), Evaluation based on Distance from Average Solution (EDAS Method), Preference Selection Index (PSI Method), Multi-Attributive Border Approximation area Comparison (MABAC Method), Complex Proportional Assessment (COPRAS Method), the simple Multi-Attribute Rating Technique Method (SMART Method), the Profile Matching Method (PM Method), the ELECTRE Method, the PROMETHEE Method, or other methods.

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