Information Fusion for the Training of Public Administrators: Design of a Composite Indicator through the Integration of AHP and TOPSIS Methods

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Abstract

The article addresses the importance of capacity development among public administrators to ensure the efficient functioning of the state and the provision of quality services to the citizenry. This entails acquiring legal knowledge, ethical principles, and technical skills in areas such as strategic planning, financial management, and policy evaluation. In addressing the evaluation of public administrators' training programs, the Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods are employed. The methodology delineates the fundamental concepts and key equations to understand the application of these methods in evaluating public administrators' training programs. The findings underscore the significance of specific competencies in public administrators' training. These competencies, combined with comprehensive training encompassing cognitive, attitudinal, and instrumental dimensions, can equip professionals to confront current governmental challenges effectively. The article emphasizes the relevance of capacity development among public administrators and introduces methods such as AHP and TOPSIS to assess and enhance training programs in this field, aiming to bolster the state's capacity to respond efficiently to societal needs.

Keywords: Public administration; AHP; TOPSIS; public capabilities.

1. Introduction

Developing public capacities among public administrators is fundamental to ensure the efficient functioning of the state and the provision of quality public services to the citizenry. In an increasingly complex and changing context, public administrators must possess specific skills that enable them to effectively manage resources and address the inherent challenges of public administration.

First and foremost, these capacities entail a deep understanding of the legal and regulatory framework within which public institutions operate, as well as the principles of transparency, accountability, and ethics that should guide their actions. Additionally, public administrators must possess technical skills in areas such as strategic planning, financial management, policy evaluation, and human resource management.

Furthermore, it is crucial for public administrators to develop competencies related to evidence-based decision-making and the efficient use of information and technology to enhance service delivery and informed decision-making. This includes the ability to analyze data, identify trends, and design effective strategies to comprehensively and sustainably address public issues. [1], [2]

Furthermore, in an increasingly interconnected world, public administrators must possess effective communication skills and the ability to collaborate with other stakeholders, both within and outside the public sector, including civil society, the private sector, and academia. The capacity to build alliances and foster consensus is essential for promoting sustainable development and democratic governance. [3]

1.1 Relevance of applying the AHP and TOPSIS methods

The Analytic Hierarchy Process (AHP) method and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are two widely used techniques in multi-criteria decision-making. They are particularly

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relevant in the evaluation of training programs due to their ability to handle multiple criteria and alternatives in a structured and systematic manner.

The AHP method is an approach that allows breaking down a complex problem into a hierarchy of criteria and sub-criteria and then uses expert opinions to assign relative weights to each criterion and sub-criterion based on their relative importance. Through pairwise comparisons and preference matrices, AHP facilitates decision-making by providing an analytical framework for evaluating and weighing the different factors influencing a decision.

For the evaluation of training programs, AHP can be used to identify and rank the most relevant criteria for assessing the effectiveness of a program, such as content quality, instructor experience, support infrastructure, cost, and impact on participants' skill development. By assigning weights to these criteria according to their relative importance, AHP helps decision-makers prioritize the most critical aspects of the program and allocate resources more efficiently.

On the other hand, the TOPSIS method is a technique that aims to identify the best alternative among a set of options based on their proximity to the ideal solution and their distance from the anti-ideal solution. To do this, TOPSIS uses the Euclidean distance or some other measure of similarity to calculate the relative distance of each alternative to the ideal solution and the anti-ideal solution in a multidimensional space defined by the evaluation criteria.

In the current case related to the evaluation of training programs, TOPSIS can be used to compare and rank different programs based on their performance relative to the pre-defined criteria. By calculating the distance of each program to the ideal and anti-ideal solutions, TOPSIS provides an objective measure of the relative quality of each alternative and helps identify those that are closer to excellence in terms of the established criteria.

Based on the above, the present research aims to determine an indicator using the AHP and TOPSIS methods, through which public administration training programs can be improved.

2. Methodology

2.1 Analytical Hierarchical Process (AHP)

The AHP is based on constructing a hierarchy that represents the structure of the decision-making problem. At the top of the hierarchy lies the objective sought to be achieved when solving the problem, while at the bottom, the various alternatives among which a decision must be selected are listed. The intermediate levels of the hierarchy detail the criteria and attributes to be considered in the decision-making process [4]. To better understand this method, it is important to define the following concepts:

Definition 1: The neutrosophic set N is characterized by three membership functions, which are the truth membership function TA, the indeterminacy membership function IA, and the falsity membership function FA, where U is the Universe of Discourse $\forall x \in U$, TA(x), IA(x), FA(x) $\subseteq [-0,1+]$, and $0 \leq \inf TA(x) + \inf IA(x) + \inf FA(x) \leq \sup TA(x) + \sup IA(x) + \sup FA(x) \leq 3+$. Note that, according to the definition, TA(x), IA(x), and FA(x) are standard or non-standard real subsets of [-0,1+], and therefore, TA(x), IA(x), and FA(x) can be subintervals of [0,1].

Definition 2: The Single Valued Neutrosophic Set (SVNS) N over U is A = {<x; TA(x), IA(x), FA(x)>: x∈U}, where TA: U→[0,1], IA: U→[0,1], and FA: U→[0,1], $0 \leq TA(x) + IA(x) + FA(x) \leq 3$. The Single Valued Neutrosophic Number (SVNN) is represented by N = (t, I, f), such that $0 \leq t, I, f \leq 1$ and $0 \leq t + I + f \leq 3$.

Definition 3: The trapezoidal single valued neutrosophic number, $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set of R, whose truth, indeterminacy, and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

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$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3 \le a_4$.

Definition 4: Given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ as two single-valued neutrosophic trapezoidal values and λ any non-zero number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (4)

Division: $\tilde{a}^{-1} = \langle (a_4^{-1}, a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.

Multiplication according to numerical scale:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$

Definitions 3 and 4 refer to the single-value neutrosophic number in situations where the condition $a_2 = a_3$ is met. For simplicity, the neutrosophic triangular value scale is used, found in Table 1, and subsequently compared with the scale shown [5]. At the most basic level, it is about understanding decision options. The assessment of the importance or weighting of the criteria is carried out through pairwise comparisons between them. These comparisons are made using a scale, as described in equation (6).

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1, 3, 5, 7, 9\right\} \quad (5)$$

Therefore, decision-making indeterminacy can be modeled by applying neutrosophic AHP, or NAHP for short. Equation 6 contains a generic pairwise neutrosophic comparison matrix:

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (6)$$

Matrix $\tilde{A}$ must satisfy the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of definition 4. To convert neutrosophic triangular numbers into sharp numbers, there are two indices defined in [5]. They are the so-called score and precision indices, respectively, see equations 7 and 8:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (7)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (8)$$

Table 1: Saaty scale translated into a neutrosophic triangular scale. Source: [5]

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle (1, 1, 1); 0.50, 0.50, 0.50 \rangle$
3	Slightly influential	$\tilde{3} = \langle (2, 3, 4); 0.30, 0.75, 0.70 \rangle$
5	Strongly influential	$\tilde{5} = \langle (4, 5, 6); 0.80, 0.15, 0.20 \rangle$
7	Very strongly influential	$\tilde{7} = \langle (6, 7, 8); 0.90, 0.10, 0.10 \rangle$
9	Absolutely influential	$\tilde{9} = \langle (9, 9, 9); 1.00, 1.00, 1.00 \rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle (1, 2, 3); 0.40, 0.65, 0.60 \rangle$ $\tilde{4} = \langle (3, 4, 5); 0.60, 0.35, 0.40 \rangle$ $\tilde{6} = \langle (5, 6, 7); 0.70, 0.25, 0.30 \rangle$ $\tilde{8} = \langle (7, 8, 9); 0.85, 0.10, 0.15 \rangle$

Beginning the process by selecting a group of qualified specialists. Next, the neutrosophic comparison matrix is structured, encompassing factors, subfactors, and strategies, using the linguistic terms specified in Table 1. The neutrosophic scale is configured based on the opinions provided by the experts. This neutrosophic comparison matrix consists of the neutrosophic triangular assessments of the factors, subfactors, and strategies.

Subsequently, a verification of the consistency of the evaluations made by the experts is carried out. If it is shown that the pairwise comparison matrix is transitive, then it is considered consistent and focuses exclusively on the lower, middle, and upper values of the neutrosophic triangular assessment for each comparison.

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Finally, the weights assigned to the factors in the pairwise neutrosophic comparison matrix are calculated. This is achieved by transforming the matrix into a deterministic form, and both the score and the degree of precision are obtained.

Additionally, the classification of priorities must be determined through the eigenvector X, based on the previous matrix by normalizing the entries of the column by dividing each entry by the sum of the column. Then, the total row averages are calculated, taking into account that Step 3 involves considering the use of the Consistency Index (CI) calculation when applying this technique, which is a function dependent on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that the consistency of evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1}, \tag{9}$$

where n is the order of the matrix. Furthermore, the Consistency Ratio (CR) is defined by the equation:

$$CR = \frac{CI}{RI} \tag{10}$$

RI is given in Table 2.

Table 2: RI associated with each order. Source: own elaboration.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

If RC ≤ 0.1, the experts' evaluation can be considered sufficiently consistent, and therefore the procedure is deemed valid.

2.2 TOPSIS method

The TOPSIS method [6], [7] establishes that the ideal solution is one where all attribute values correspond to the optimal values of each attribute among the alternatives [8]; the anti-ideal solution is the one where all attribute values correspond to the least desired values of each attribute among the alternatives [9]. In this manner, TOPSIS provides a solution that is not only the closest to a hypothetically better solution but also the furthest from the hypothetically worse one [10], [11]. The process is described below:

1. Determine the objective and identify the attributes to evaluate.
2. Prepare a matrix based on the available information about the attributes. Each row corresponds to an alternative and each column to an attribute. The element x_{ij} of the matrix represents the non-normalized value of the *j-th* attribute for the *i-th* alternative.
3. Calculate the normalized decision matrix *Rij*. This is obtained by dividing each attribute value XI by the square root of the sum of the squares of each attribute value XJ. This is mathematically represented by equation (11):

$$Rij = \frac{x_{ij}}{\sqrt{\sum_{m=1}^{k} x_{mj}^2}} \tag{11}$$

4. Determine the relative importance or weight of each attribute with respect to the objective. This results in a set of weights wj (for j = 1,2,…, J) such that ∑wj = 1. The weights are generally based on expert judgments and should reflect the relative importance assigned to the evaluated performance attributes. The range of possible values for wj will only be limited by the ability of the decision group members to distinguish the relative importance of the analyzed performance attributes.
5. Obtain the normalized and weighted matrix Vij. This is done by multiplying each element of the columns of the matrix Rij by its corresponding weight wj. Therefore, the elements of the normalized and weighted matrix are expressed by equation 12.:

$$V_{ij} = w_j * R_{ij} \tag{12}$$

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6. Obtain the ideal and anti-ideal solutions: The ideal solution can be expressed as: (13) and the anti-ideal as (14). VJ+ indicates the ideal value of the attribute considered among the attribute values for the different alternatives, while VJ- indicates the worst value of the attribute considered among the attribute values for the different alternatives.

$$V^{+} = \{V_1^{+}, V_2^{+}, V_3^{+}, \dots, V_j^{+}\} \quad (13)$$

$$V^{-} = \{V_1^{-}, V_2^{-}, V_3^{-}, \dots, V_j^{-}\} \quad (14)$$

7. Calculate the Euclidean distances of each alternative to the ideal and anti-ideal solutions using the following equations:

$$D_i^{+} = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^{+})^2} \quad (15)$$

$$D_i^{-} = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^{-})^2} \quad (16)$$

8. The relative closeness Pi of a particular alternative to the ideal solution is expressed by (17):

$$P_i = \frac{D_i^{-}}{(D_i^{+} + D_i^{-})} \quad (17)$$

9. In this step, a set of alternatives is generated in descending order according to the value of Pi, with the best alternative being the one with the highest value of Pi.

3. Results

Training for public administrators should be designed to provide advanced competencies that enable professionals to excel in creating, updating, and developing public capacities. These competencies, combined with a solid theoretical and practical foundation in public administration, can prepare professionals to face challenges and seize opportunities in a constantly changing and evolving government environment.

It is important to note that training in Public Administration, aimed at developing public capacities, should foster comprehensive education that includes not only cognitive, attitudinal, and instrumental dimensions but also the axiological dimension, equipping future graduates with the tools for a performance characterized by a critical and transformative attitude towards their social environment.

Experts agree that the following areas should be analyzed using the neutrosophic version of the AHP method (Tables 3 and 4):

1. Leadership and Change Management: Competence to lead organizational change processes in government environments, promoting the adoption of new practices and cultures that enhance the efficiency and effectiveness of the public sector.
2. Public Policy Management: Ability to design, implement, and evaluate public policies that address the needs and demands of society, integrating innovative and sustainable approaches.
3. Strategic Analysis: Capacity to analyze the political, economic, social, and technological environment to identify opportunities and threats, and formulate effective strategies for the development of public capacities.
4. Human Resources Management: Ability to manage multidisciplinary and diverse teams, fostering a collaborative and motivating work environment, and developing the human talent necessary to achieve institutional objectives.
5. Public Financial Management: Advanced knowledge in budgetary, financial, and fiscal management of the public sector, ensuring efficiency in resource utilization and transparency in accountability.
6. Quality Management and Results Evaluation: Competence to implement quality management systems and evaluate the performance of public programs and projects, ensuring continuous improvement and the achievement of tangible and measurable results.

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Table 3: Application of neutrosophic AHP. Source: own elaboration.

Alternatives	Leadership and change management	Public policy management	Strategic analysis	Human resources management	Public financial management	Quality management and results evaluation
Leadership and change management	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
Public policy management	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩
Strategic analysis	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$
Human resources management	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$
Public financial management	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
Quality management and results evaluation	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	⟨(1,1,1); 0.50,0.50,0.50⟩

Table 4: Deneutrosophied paired comparison matrix. Source: own elaboration.

Criteria	Leadership and change management	Public policy management	Strategic analysis	Human resources management	Public financial management	Quality management and results evaluation	Weight
Leadership and change management	0.9375	5.1562	5.1562	5.1562	2.6437	2.6437	0.334410
Public policy management	0.2120	0.9375	5.1562	2.6437	0.3182	0.9375	0.096940
Strategic analysis	0.2120	0.2120	0.9375	2.6437	0.3182	0.2120	0.050220
Human resources management	0.2120	0.3182	0.3182	0.9375	0.2120	0.2120	0.035719
Public financial management	0.3182	2.6437	2.6437	5.1562	0.9375	2.6437	0.208733
Quality management and results evaluation	0.3182	0.9375	5.1562	5.1562	0.3182	0.9375	0.127504

As can be observed, the matrix has an eigenvalue of 5.46869, with a CI of 0.058115 and CR of 5.7863. The results were presented to a panel of experts, where a greater preference towards strategic analysis was determined.

From this point forward, the weights are ready to be used for applying the TOPSIS method to delve deeper into the study of elements specific to the competency preferred by the experts. Thus, eight specific alternatives for the "Leadership and Change Management" competency are evaluated, which are relevant for the training of public administrators in the creation, updating, and development of public capacities (Table 5):

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Table 5: Alternatives for the study of the Leadership and Change Management competency. Source: own elaboration.

Alternatives	Description
Understanding of the institutional context	Assess the public administrator's ability to analyze and understand the political, economic, and social environment in which the public institution operates.
Identification of problems and opportunities	Assess the administrator's skill in identifying accurately and timely the problems and opportunities faced by the public organization within its context.
Analysis of trends and external factors	Assess the administrator's capability to analyze relevant trends and external factors that may impact the performance and capacity of the public organization to fulfill its mission and objectives.
Formulation of strategic objectives	Assess the administrator's ability to establish clear and achievable strategic objectives aligned with the vision and mission of the public organization.
Identification of strategic alternatives	Assess the administrator's capacity to generate and evaluate different strategic alternatives to address identified problems and leverage identified opportunities.
Analysis of risks and vulnerabilities	Assess the administrator's ability to identify and analyze the risks and vulnerabilities associated with each strategic alternative, as well as their potential impact on the public organization.
Selection of appropriate strategies	Assess the administrator's capability to select and implement the most appropriate strategies to achieve established objectives, considering available resources and environmental constraints.
Monitoring and evaluation of results	Assess the administrator's capacity to continuously monitor and evaluate the progress and outcomes of the implemented strategy, and to adjust it as necessary to ensure its effectiveness and adaptability.

These assessment alternatives are necessary to measure competence in strategic analysis among public administrators, thus ensuring effective measures for their training and capacity development. Likewise, they aid in effectively measuring competence in leadership and management by providing clear guidance for their development and performance in governmental environments. Table 6 displays the selected criteria for these purposes, along with the relative weights assigned by the experts.

Table 6: Evaluation criteria and weights assigned by experts. Source: Own elaboration

Evaluation Criteria	Weights
Practical Applicability	0.250
Content Relevance	0.150
Update	0.250
Teaching Methodology	0.350

Table 7 shows the normalized and weighted matrices constructed following the logic of the method.

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Table 7: Normalized and Weighted Matrix. Source: Own elaboration

Normalized matrix				
Alternatives	Practical applicability	Content Relevance	Update	Teaching methodology
Understanding of the institutional context	0.549	0.464	0.204	0.099
Identification of problems and opportunities	0.329	0.279	0.408	0.296
Analysis of trends and external factors	0.329	0.279	0.204	0.296
Formulation of strategic objectives	0.220	0.279	0.204	0.296
Identification of strategic alternatives	0.329	0.371	0.306	0.394
Analysis of risks and vulnerabilities	0.329	0.371	0.306	0.296
Selection of appropriate strategies	0.329	0.371	0.510	0.493
Monitoring and evaluation of results	0.329	0.371	0.510	0.493
Weighted Matrix				
Understanding of the institutional context	0.137	0.137	0.055	0.027
Identification of problems and opportunities	0.082	0.082	0.110	0.082
Analysis of trends and external factors	0.082	0.082	0.055	0.082
Formulation of strategic objectives	0.055	0.082	0.055	0.082
Identification of strategic alternatives	0.082	0.110	0.082	0.110
Analysis of risks and vulnerabilities	0.082	0.110	0.082	0.082
Selection of appropriate strategies	0.082	0.110	0.137	0.137
Monitoring and evaluation of results	0.082	0.110	0.137	0.137

Subsequently, using equations (15) and (16), positive and negative ideal values are determined, as shown in Table 8.

Table 8: Positive and Negative Ideal Values. Source: Own elaboration

Criteria	**D+**	**D-**
Practical applicability	0.137	0.055
Content Relevance	0.137	0.082
Update	0.137	0.055
Teaching methodology	0.137	0.027

The TOPSIS method ranks each alternative based on the degree of relative proximity to the positive ideal value and the distance from the negative ideal value. Therefore, in this step, the calculation of the distances between each alternative and the positive and negative ideal solutions is shown in Table 9.

Table 9: Positive and Negative Ideal Distances and Relative Proximity (Pi). Source: Own elaboration

Alternatives	**d+**	**d-**	**Pi**	**Priority**
Understanding of the institutional context	0.021	0.011	0.427	2
Identification of problems and opportunities	0.013	0.004	0.345	4
Analysis of trends and external factors	0.019	0.001	0.210	6
Formulation of strategic objectives	0.023	0.001	0.139	7

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Identification of strategic alternatives	0.010	0.005	0.401	3
Analysis of risks and vulnerabilities	0.013	0.003	0.328	5
Selection of appropriate strategies	0.005	0.012	0.603	1
Monitoring and evaluation of results	0.005	0.012	0.610	1

As seen in Table 9, the results of the applied method indicate that, according to the analyzed criteria, the selection of appropriate strategies and the monitoring and evaluation of results are the most relevant elements in the analysis of leadership and change management. On the other hand, understanding the institutional context and identifying strategic alternatives are among the methods that prove to be effective components in leadership and change management.

4. Conclusion

This scientific article emphasizes the importance of developing public capacities in public administrators. It seeks to ensure the efficient functioning of the state and the provision of quality public services to citizens in an increasingly complex and changing context. The need for specific skills that allow for the effective management of resources and the addressing of inherent challenges in public administration is underscored. The relevance of the Analytic Hierarchy Process method and TOPSIS in evaluating training programs for public administrators is highlighted as analytical tools that facilitate decision-making. The research presents a proposal to determine an indicator endorsed by these methods, aiming for effectiveness in implementing measures in public administrator training programs. The relevant criteria for evaluating the effectiveness of these programs include leadership and change management, public policy management, strategic analysis, human resource management, public financial management, quality management, and results evaluation. Therefore, the importance of strengthening public capacities to promote better performance in management and ensure the achievement of institutional objectives in an environment characterized by complexity and constant change is emphasized.

References

[1] V. Kondratenko, O. Okopnyk, L. Ziganto, and A. Kwilinski, “INNOVATION DEVELOPMENT AND EFFICIENCY OF PUBLIC ADMINISTRATION: MANAGEMENT AND LEGISLATION FEATURES.,” *Mark. Manag. Innov.*, no. 1, pp. 87–94, 2020, [Online]. Available: https://www.researchgate.net/profile/Aleksy-Kwilinski/publication/340892029_Innovation_Development_of_Public_Administration_Management_and_Legislation_Features/links/5ebfefb6a6fdcc90d67a4b8e/Innovation-Development-of-Public-Administration-Management-and-Legislation-Features.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail&_rtd=e30%3D

[2] G. Žurga, “Contemporary values in public administration and indication of their further development,” *Adm. si Manag. Public*, no. 29, pp. 108–127, 2017, [Online]. Available: https://www.ceeol.com/search/article-detail?id=728395

[3] C. A. Drolc and L. R. Keiser, “The importance of oversight and agency capacity in enhancing performance in public service delivery,” *J. Public Adm. Res. Theory*, vol. 31, no. 4, pp. 773–789, 2021, [Online]. Available: https://academic.oup.com/jpart/article/31/4/773/6042803?login=false

[4] A. B. Bonilla Rodríguez, M. F. Cueva Moncayo, and F. B. Morocho Quinchuela, “Construction of Sanda Teaching risk assessment index system using neutrosophic AHP method.,” *Int. J. Neutrosophic Sci.*, vol. 18, no. 4, pp. 334–343, 2022, [Online]. Available: https://americaspg.com/articleinfo/21/show/1196

[5] M. Abdel-Basset, M. Mohamed, and F. Smarandache, “An extension of neutrosophic AHP–SWOT analysis for strategic planning and decision-making,” *Symmetry (Basel).*, vol. 10, no. 4, p. 116, 2018, [Online]. Available: https://www.mdpi.com/2073-8994/10/4/116

[6] M. Ramos Argilagos, A. Valencia Herrera, and W. Vayas Valdiviezo, “Evaluation of Nutritional Education Strategies in Schools in Ecuador Using Neutrosophic TOPSIS,” *Int. J. Neutrosophic Sci.*, vol. 18, no. 3, pp. 208–217, 2022, doi: https://doi.org/10.54216/IJNS.1803018.

[7] S. Alvarez Hernandez, P. P. Jairo Mauricio, and L. Vázquez Maike, “Neutrosophic TOPSIS for prioritization Social Responsibility Projects.,” *Int. J. Neutrosophic Sci.*, vol. 19, no. 1, pp. 350–362, 2022, [Online]. Available: https://americaspg.com/articleinfo/21/show/1286%0A

Doi: https://doi.org/10.54216/IJNS.230433
Received: June 22, 2023 Revised: January 21, 2024 Accepted: March 19, 2024

[8] P. Biswas, S. Pramanik, and B. C. Giri, "TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment.," *Neural Comput. Appl.*, vol. 27, no. 3, pp. 727–737, 2016, [Online]. Available: https://link.springer.com/article/10.1007/s00521-015-1891-2

[9] S. Opricovic & Tzeng, G. H., "Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS.," *Eur. J. Oper. Res.*, vol. 156, no. 1, pp. 445–455, 2004, [Online]. Available: https://doi.org/10.1016/S0377-2217(03)00020-

[10] Surinder Kaur, Javalkar D. Kumar, Gopal Chaudhary, An innovative multi-criteria decision-making framework for assessing India's airport operating efficiency, Journal of Fusion: Practice and Applications, Vol. 4 , No. 2 , (2021) : 72-85 (Doi : https://doi.org/10.54216/FPA.040204)

[11] R. E. Alvarado Chacón, A. Rodríguez Plasencia, and O. M. Alonzo Pico, "Neutrosophic Analysis of the Nursing Care Process in the Teaching of Nursing," *Neutrosophic Sets Syst.*, vol. 52, pp. 207–214, 2022, [Online]. Available: http://fs.unm.edu/NSS/22-NeutrosophicAnalysisNursingCare.pdf%0A

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