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APPLICATIONS TO THE PUBLIC SECTOR SPECIAL ISSUE ARTICLES

RANKING OF INSTRUCTORS IN A BRAZILIAN AIR FORCE SCHOOL USING THE AHP AND TOPSIS METHODS

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ABSTRACT. The selection process for instructors at the Brazilian Air Force Officers Improvement School (EAOAR) needs improvement to provide clearer guidance to the Commandant. This article aims to streamline and enhance the process by making it more efficient, less subjective, and more reliable. Researchers employed the Analytic Hierarchy Process (AHP) to determine criteria weights and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to rank candidates. They used Three Decision Methods (3DM) Software Web (v.1) for efficient calculations. Results showed that candidates closer to the Positive Ideal Solution (PIS) received favorable indications, while those closer to the Negative Ideal Solution (NIS) faced rejections. The AHP-TOPSIS hybrid approach successfully ranked candidates and expedited the process. Moreover, this approach has broader applications, including assessing candidates for international missions in the Brazilian Navy and Army, and evaluating employee performance in any organization. Future research could explore classification methods like the ELECTRE-TRI.

Keywords: AHP-TOPSIS methods, Brazilian Air Force, personnel selection.

1 INTRODUCTION

The Officers Improvement School (EAOAR), as designated by the Brazilian Instructors of the Inter-American Air Forces Academy (IAAFA), plays a crucial role in providing ongoing training to Subaltern and Intermediate Officers in the Brazilian Air Force (FAB), preparing them to serve as advisors within various military organizations of the Force (Da Silva et al. 2022). The model of this School adheres to the concept of an ambidextrous organization, since it combines the application of already consolidated knowledge with the exploration of new knowledge necessary for student training in an environment with rapid sociocultural, technological, political, and

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economic changes. In addition, it can combine elevated levels of efficiency, through the standardization of teaching processes, with the flexibility to evolve and innovate in its didactic practices (Adler et al. 2009).

Attending the Officers Improvement Course (CAP) offered by EAOAR is a mandatory requirement for those seeking promotion to the Senior Officer rank. The faculty comprises instructors who are chosen from within the training classes themselves (Da Silva et al. 2022). Historically, around two-fifths of CAP graduates have their indication approved by the School Commandant because they have the desired skills as an instructor. This decision-making process allows the renewal of the faculty of the School, seeking an alignment with the intrinsic values of the organization, as suggested by Keeney (1992).

However, some opportunities for improvement in this process are observed, such as the average of the classes in the evaluation of the disciplines taken in the last five years is 9.314 (on a scale of 0.000 to 10.000) with almost all students remaining with the individual average above 9.000. One interesting observation is that exceptional academic performance alone may not necessarily disqualify the student who ranks last in the class from being considered for the role of instructors in the school. Furthermore, the selection process seems to downplay the importance of other criteria, as they are not fully considered during the decision-making process (Da Silva et al. 2022). It's worth pointing out that the decision-maker seeks to identify officers who closely match the ideal profile of an instructor while distancing themselves from those who do not.

The objective of this research is to enhance the decision-making procedure by introducing an ordering mechanism that accounts for the significance of all the criteria employed, thereby providing more transparency in the recruitment of new instructors. Considering the emerging demands in the current context, the following guiding question of this research is presented: how does an alternative ordering model allows improving the process of appointing new EAOAR instructors? Therefore, this study is inserted in a problem of multicriteria decision making (MCDM).

In this sense, the initial hypothesis was that the use of a hybrid approach of the Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods could result in a satisfactory solution to the decision-making problem. The aim of this study is to evaluate and rank 67 candidates who participated in the instructor appointment process for CAP 1/2021 between April and July 2021. The evaluation was based on the six criteria that are currently employed by EAOAR.

In addition to this introduction, this article presents in Section 2 a theoretical framework elaborated from bibliographic research in the Scopus database, on the methods Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) applied in personnel selection problems. In Section 3, a framework of the decision-making process is presented, as well as the results found. In Section 4 an analysis of these results is made. Section 5 brings the final considerations and some perspectives on the work. Finally, in Section 6, EAOAR is thanked for the support in the implementation of the methodology.

2 THEORETICAL FRAMEWORK

The Scopus database was chosen to carry out the research on the theoretical framework of this work, as it consists ”in the largest database of abstracts and citations of literature reviewed by peers, with bibliometric tools to monitor, analyze and visualize the research” (Scopus 2016). There were searches of documents containing related expressions of the main theoretical axes of the research, in their titles, abstracts and keywords.

The Scopus database received the subsequent search query: TITLE-ABS-KEY ((”Human Talent Selection” OR ”Personnel Selection”) AND (”Analytic Hierarchy Process” OR AHP OR ”Funfamental Scale of Saaty”) AND (”Technique for Order Preference by Similarity to Ideal Solution” OR TOPSIS)). It was possible to observe that, although the terms related to Personnel Selection and the AHP and TOPSIS methods are many found alone in the database, there are only 13 works that address a combination of thematic axes from 2003 to 2022. This finding reveals a theoretical gap that justifies further research on using such methods in people selection problems.

From this generic search in the Scopus database, it was defined that only articles from the last five years, that is, from 2018 to 2022, would be included in the theoretical foundation of this work. Thus, 7 articles were included, as shown in Table 1.

Table 1 – Articles included in the theoretical foundation.

Authors	Document title
Danişan et al. (2022)	Personnel Selection with Multi-Criteria Decision-Making Methods in the Ready-to-Wear Sector
Nong & Ha (2021)	Application of MCDM methods to Qualified Personnel Selection in Distribution Science: Case of Logistics Companies
Petridis et al. (2021)	Internal auditor selection using a TOPSIS/non-linear programming model
Dwivedi et al. (2020)	Efficient team formation from pool of talent: comparing AHP-LP and TOPSIS-LP approach
Abdel-Basset et al. (2020)	A bipolar neutrosophic multi criteria decision making framework for professional selection
Nabeeh et al. (2019)	An Integrated Neutrosophic-TOPSIS Approach and Its Application to Personnel Selection: A New Trend in Brain Processing and Analysis
Samanlioglu et al. (2018)	A Fuzzy AHP-TOPSIS-Based Group Decision-Making Approach to IT Personnel Selection

Danişan et al. (2022) addressed the problem of personnel selection for working in a textile factory that requires the use of machines with specific characteristics. To select the most suitable candidate for the job, the authors used multicriteria decision-making methods to ensure an analytical and objective choice. The weights of important criteria for the factory were determined using the AHP (Saaty 1980), while the Weighted Scoring (WS) method was used for preselection (Russell & Taylor 2003). The TOPSIS (Hwang & Yoon 1981) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) methods were employed for the correct selection among candidates (Brans et al. 1986). The study stands out for the combination of methods and criteria evaluated, but in the practical context of EAOAR this combination could frustrate the decision maker, finding the application of the methods complex.

In their study, Nong & Ha (2021) aimed to propose an integrated MCDM model to support the selection of qualified personnel in the distribution area. The integrated approach of AHP (Saaty 1980) and TOPSIS (Hwang & Yoon 1981) was used to solve the personnel selection problem, in which a new hybrid model was implemented to help a logistics company identify the most suitable candidates for the role of sales manager.

According to their findings, this Nong & Ha (2021) model offers decision makers a more efficient and effective solution compared to traditional methods, saving time and improving results. This study advances in understanding human resource management and logistics management by incorporating a range of selection criteria, which can be very useful in the context of EAOAR.

Petridis et al. (2021) addressed the problem of selecting internal auditors in a Greek multinational company, which requires specific cognitive and behavioral skills. His study proposes the AHP technique (Saaty 1980) to determine the weights of each criterion, and a structure for the selection of internal auditors using the TOPSIS technique (Hwang & Yoon 1981), which integrates cognitive and behavioral skills to classify candidates. The study also examines the importance of cognitive and behavioral skills that maximize the performance of each candidate. This real case of hybrid application of AHP and TOPSIS methods can also be particularly useful in maximizing the performance of EAOAR instructor candidates.

Dwivedi et al. (2020) developed a model aimed at selecting the best candidates for a supply chain company that planned to expand its business. The study was conducted at a supply chain company in northern India and analyzed 38 candidates. The researchers used integrated methods AHP-LP and TOPSIS-LP to evaluate and implement the personnel selection model. Linear programming (LP) was selected due to its common use in optimization and allocation problems, and the AHP and TOPSIS methods were combined separately with the LP model to determine the optimal solution. The AHP-LP and TOPSIS-LP approaches were compared and integrated to determine the most appropriate model. The results showed that both approaches were feasible to select the best candidate, but AHP was more reliable while TOPSIS was easier to implement. The integrated approach of ranking and optimization proved to be feasible and able to suggest relevant positions to form an efficient team, such as that sought in the process of appointing instructors from EAOAR.

According to Abdel-Basset et al. (2020), professional selection is a crucial task for organizations seeking to fill vacancies with the most suitable candidates. The recruitment process involves several individual characteristics, including leadership, analytical skills and personality, among others, which is also observed in the decision-making context of the appointment of new EAOAR instructors. These authors propose a new multicriteria neutral hybrid decision structure for CEOs selection using a collection of Analytical Network Process (ANP) and TOPSIS methods to address this issue. The proposed approach allows an accurate personnel selection and is compared with other related works to validate the results, such as Weight Sum Model (WSM), Weight Product Model (WPM) (Triantaphyllou 2000), AHP (Saaty 1980) Optimization Based on Simple Ratio Analysis (MOORA) (Brauers & Zavadskas 2006). This corroborates the proposed hybrid use of AHP and TOPSIS methods to select new instructors.

According to Nabeeh et al. (2019), personnel selection is crucial to the success of any company, but the process of choosing the most suitable candidate among multiple candidates is complex and confusing for decision makers due to numerous criteria, alternatives and objectives. In their article, these authors propose a solution integrating the Neutrosophical AHP (Abdel-Basset et al. 2017) with TOPSIS (Hwang & Yoon 1981) for personnel selection. This proposed hybrid method shows a significant improvement in the personnel selection process compared to traditional decision-making methods, especially in relation to resource management and achievement of company goals. However, given the traditional characteristics of the EAOAR decision maker, the sophistication of the Neutrosophical AHP method can create cognitive barriers in the decision-making process.

In their article, Samanlioglu et al. (2018) discuss the personnel selection process in the IT department of a Turkish dairy company, using the methods Fuzzy AHP (Güngör et al. 2009) and Fuzzy TOPSIS (Kaya & Kahraman 2011). Their goal was to select the best candidate for the job by incorporating these methods with Chang's extension analysis and verbal evaluations of decision makers, using Fuzzy intuitionist numbers (Boran et al. 2011). Hierarchical level weights are used during the group decision-making process, reflecting the importance of verbal evaluations of decision makers. Although this approach is interesting for group decision making, the organizational culture of EAOAR requires an incremental implementation of new decision-making methods, so that the decision maker and his advisors gain confidence in the proposed methodology. Thus, the analyst suggests that the hybrid application of traditional AHP and TOPSIS methods should be first consolidated at EAOAR, so that stakeholders become familiar with multicriteria decision-making methods (MCDM) before applying more sophisticated methods.

Given this theoretical foundation, this work applied a hybrid methodological approach, using, as they were originally conceived, the AHP method for establishing weights and TOPSIS for ranking alternatives, that is, the 67 CAP student officers.

3 ANALYTIC HIERARCHY PROCESS (AHP)

The AHP approach involves drawing insights from how people make decisions when faced with complex problems. By adopting this method, one can account for both concrete and abstract aspects of decision-making, as it permits the creation of scales for qualitative factors that rely on the subjective viewpoints of decision-makers (Saaty 1980).

Saaty (1991) claims that the AHP method is based on a hierarchical analysis of variables. The set of alternatives is evaluated according to the decision-maker's preference structure, based on an inter-criteria evaluation for the definition of value scales (weights). Saaty (1980) proposed a fundamental scale to transform the decision-maker's verbal scale into a numerical scale, as shown in Table 2. If one criterion is n times more important than another, then the reciprocal value is $\frac{1}{n}$. The intra-criterion evaluation is related to the performance of the alternatives in the criteria.

Table 2 – Saaty Fundamental Scale (Saaty, 1980).

Intensity of Importance	**Definition**	**Explanation**
1	Equal Importance	Two factors contribute equally to the objective.
3	Moderate Importance	Experience and judgement slightly favour one factor over another.
5	Strong Importance	Experience and judgement strongly favour one factor over another.
7	Very Strong Importance	One factor is strongly favoured and its dominance demonstrated in practice.
9	Extreme Importance	The evidence favouring one factor over another is of the highest possible validity.
2, 4, 6, 8	Intermediate Values	When compromise is needed in assigning importance between two adjacent values.

According to Saaty (1991), the criteria are compared pair by pair and then the consistency of these comparisons is evaluated. Thus, following the rule of transitivity, let A, B, and C be criteria for a given decision-making problem. If $A > B$ and $B > C$, then: $A > C,\ \forall\, A,\ B,\ C \in\ \mathbb{R}$. Saaty (1980) admits a maximum inconsistency of 10% . The AHP method enables the calculation of a Consistency Ratio (CR), by comparing the Consistency Index (CI) of the decision-maker's attributions, with the Consistency Index of a random matrix (RI), according to Equation 1. Saaty (1980) provided the RI values, as shown in Table 3.

$$CR = \frac{CI}{RI} \tag{1}$$

Table 3 – Random consistency indices (Saaty, 1980).

Matrix order	1	2	3	4	5	6	7	...	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	...	1.57	1.59

According Saaty (1980), for the CI calculation, the $\lambda_{Max} > 0$ is considered, which is the highest eigenvalue of the matrix of judgments, according to Equation 2. Saaty and Vargas (2012) explain that the scale constants derived from the pairwise comparison matrix are obtained by solving the system of homogeneous linear equation, with $a_{ji} = \frac{1}{a_{ij}}$ and $a_{ij} > 0$. According to Bernasconi, Choirat, and Seri (2010, p.701), it is known from the Perron-Frobenius theorem that the system of Equation 3 has a unique solution, the Perron eigenvector. Furthermore, if $A = (a_{ij})$ is cardinally consistent, the maximum eigenvalue method provides the correct priority weights, and the maximum eigenvalue is at its minimum value $\lambda_{\max} = n$. When $A = (a_{ij})$ is not cardinally consistent, $\lambda_{\max} > n$.

$$CI = \frac{(\lambda_{Max} - n)}{(n-1)} \tag{2}$$

$$\sum_{j=1}^{n} a_{ij} w_j = \lambda_{Max} w_i, \qquad \sum_{i=1}^{n} w_i = 1 \tag{3}$$

According to Costa (2002), the Consistency Ratio (CR) is a tool that can be used to evaluate inconsistency resulting from the order of the judgment matrix. If the CR value exceeds 0.10, it may be necessary to review the model and/or the judgments. However, it is important to follow the well-defined steps of the AHP Method to calculate the CR.

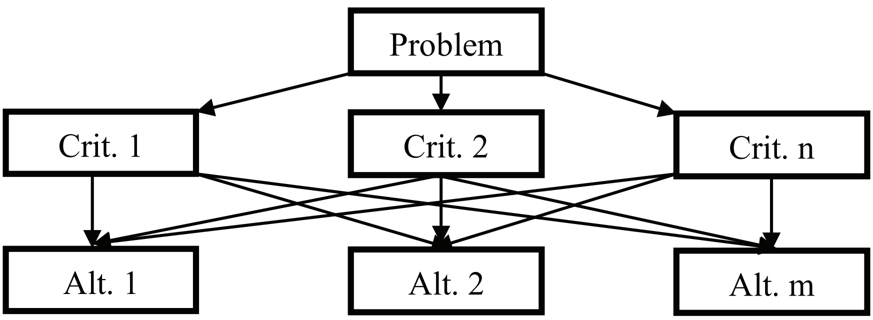

Figure 1 – Structured hierarchy of a decision problem.

Initially, from a structured hierarchy like Figure 1, it is necessary to define a decision matrix, which represents "the number of times an alternative dominates or is dominated by the others" (Araya et al. 2004). In Equation 4, this decision matrix A is represented by the values a_{ij}, where a value a is assigned to a row i, of the alternatives; combined with a column j, of the criteria.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & \cdots & a_{1j} \\ a_{21} & a_{22} & a_{23} & a_{24} & \cdots & a_{2j} \\ a_{31} & a_{32} & a_{33} & a_{34} & \cdots & a_{3j} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & a_{i3} & a_{i4} & \cdots & a_{ij} \end{bmatrix} \tag{4}$$

When the hierarchical structure of a decision problem is known, it is possible to perform a pairwise comparison of the decision criteria. Normally, this comparison is carried out based on the judgments of specialists around the analyzed decision-making problem. According to Saaty (1980), the number of parity comparisons (Npc) made by the decision-maker is calculated by Equation 5.

$$Npc = \frac{n(n-1)}{2} \tag{5}$$

The square matrix of parity comparisons C, presented in Equation 6, is built based on Saaty's Fundamental scale (Table 3), where c_{ij} represents the relative importance of attribute c_i in relation to attribute c_j, so that $c_{ij} > 1$, if and only if c_i is more important than c_j; $c_{ij} = 1$, if and only if c_i is as important as c_j; and $c_{ij} = \frac{1}{c_{ji}}$, for any pair $(i,\ j)$, obeying the reciprocity property.

$$C = \begin{bmatrix} 1 & \cdots & C_{1j} \\ \vdots & \ddots & \vdots \\ \frac{1}{C_{1j}} & \cdots & 1 \end{bmatrix} \tag{6}$$

It is important to observe that the basic property of reciprocity is respected, that is, $c_{ij} \times\ c_{ji} = 1,\ \forall_{i,\ j} \in\ \mathbb{N}^*$. Furthermore, if c_i is K_x times more important than c_j, and if c_i is K_y times more important than c_k, then c_i must be $K_x\ x\ K_y$ times more important than c_k in order to obey the proportionality property.

According to Saaty (1980), after defining the parity comparison matrix of the criteria, it is necessary to carry out a normalization procedure ($\mathrm{NAHP_{ij}}$), using Equation 7, where c_{ij} represents the relative importance of c_i in relation to c_j, and $\sum_{j=1}^{n} c_{ij}$ is the sum of the values of each column of the parity comparison matrix. The result of this procedure is a normalized matrix of judgments.

$$NAHP_{ij} = \frac{c_{ij}}{\sum_{j=1}^{n} c_{ij}} \tag{7}$$

Then, the criteria priority vector $V =\ [v_i]$ is calculated, through the arithmetic mean of the row values of the normalized judgment matrix, according to Equation 8, where $\sum_{i=1}^{n} c_{ij}$ is the sum of the row values; n is the number of decision criteria; and $\sum v_i = 1$ (Saaty 1980). This priority vector represents the weights of the criteria, but it is still necessary to verify the consistency of the judgments.

$$v_i = \frac{\sum_{i=1}^{n} c_{ij}}{n} \tag{8}$$

Thus, it is necessary to weight the matrix of parity comparisons, or matrix of judgments, using the priority vector of the criteria, obtaining the matrix of weighted judgments, according to Equation 9, where the weights of each criterion V_i are multiplied by the values of the respective columns of the matrix of judgments.

$$C_v = \begin{bmatrix} v_1 \\ \vdots \\ v_i \end{bmatrix} x \begin{bmatrix} 1 & \cdots & C_{1j} \\ \vdots & \ddots & \vdots \\ \frac{1}{C_{1j}} & \cdots & 1 \end{bmatrix} \tag{9}$$

Next, the row values of the weighted judgment matrix obtained in Equation 9 (C_v) are added. Each sum of the lines is divided by the corresponding weight of the criteria in priority vector, according to equation 10.

$$\omega_i = \frac{\sum_{i=1}^{n} c_{ij} \times v_i}{v_i} \tag{10}$$

After verifying the consistency of the decision-maker's judgments, with a $CR < 0.1$, the intra-criterion evaluation of the alternatives must be carried out, filling the decision matrix with the values corresponding to the alternatives' performances in each criterion. However, the values obtained in monotonic cost criteria must be inverted, that is, if an alternative A_i obtains an evaluation a_{ij} in each monotonic cost criterion j, then its inverse must be assigned $\frac{1}{a_{ij}}$. The values of the decision matrix must be normalized, a_{ij} through the same procedure presented in Equation 7, considering the elements a_{ij} instead of c_{ij}. In this way, the local preferences of the alternatives in relation to the criteria are obtained.

Then, the normalized decision matrix is multiplied by the priority or weight vector of the criteria, according to Equation 11. The global priority is calculated by the sum of the values obtained by each alternative, in the rows of this matrix (A_v).

$$A_v = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ \vdots \\ v_i \end{bmatrix} x \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & \cdots & a_{1j} \\ a_{21} & a_{22} & a_{23} & a_{24} & \cdots & a_{2j} \\ a_{31} & a_{32} & a_{33} & a_{34} & \cdots & a_{3j} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & a_{i3} & a_{i4} & \cdots & a_{ij} \end{bmatrix} \tag{11}$$

The global priority of alternatives by the AHP method is calculated by multiplying the local preferences of the alternatives by the respective weights of the criteria and summing the results (Saaty 1991). In other words, the global priority is given by the weighted sum of the relative priorities of the alternatives. This calculation is performed for each alternative and allows its ranking in relation to the other evaluated alternatives. In this work, the AHP method was used only to obtain the value scales of the criteria, that is, the vector of priorities or weights. To calculate the global priority of the alternatives, the TOPSIS method was used.

3.1 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The TOPSIS method was developed by Hwang & Yoon (1981) and, as De Almeida (2013) argues, this method situates the alternatives of a decision-making process, in relation to the references of an ideal point and an anti-ideal point. Thus, the best alternative is the one that keeps the minimum distance from the ideal point and the maximum distance from the anti-ideal point.

That is, as it approaches the ideal, an alternative minimizes monotonic cost criteria, while maximizing monotonic profit criteria. In contrast, the worst alternative approaches the anti-ideal since it maximizes monotonic cost criteria and minimizes monotonic profit criteria (Rodrigues et al. 2021).

The TOPSIS method is a type of multicriteria decision-making approach that allows for trade-offs between different criteria. In other words, even if one alternative performs poorly on one criterion, it may still be considered a good choice if it performs well on other criteria. To determine the best possible ranking of alternatives, TOPSIS relies on Euclidean distances between each alternative and both the ideal and anti-ideal points. This method has been widely used by decision-makers (Hwang & Yoon 1981).

Tiwar & Kumar (2021) argue about the calculation steps of the TOPSIS method. Initially, a decision matrix is constructed like that presented in Equation 4. Once the decision matrix is defined, the next step is to calculate the normalized decision matrix. Whereas each criterion is presented on a different scale than the others, Equation 12 is used to scale them on the same scale (Hwang & Yoon 1981).

$$NTOPSIS_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{n} (a_{ij})^2}} \tag{12}$$

After defining the normalized decision matrix, Equation 13 is used to calculate the weighting of the normalized decision matrix, to apply the decision-maker's preferences for different criteria, where v_j represents the weight of criterion j (Tiwar & Kumar 2021). It should be noted that the TOPSIS method does not generate weights, which must be attributed subjectively by the decision-maker himself, or through the application of another decision-making method. In the case of this work, the weights calculated by the AHP method were applied in this step of the TOPSIS method.

$$W_{ij} = v_j \times NTOPSIS_{ij} \tag{13}$$

The next step is to calculate the ideal and anti-ideal solutions, that is, the positive ideal solution (PIS) and the negative ideal solution (NIS), using Equations 14 and 15, where J^+ and J^- represent the sets of benefit and cost criteria, respectively, and $i = 1, 2, 3, \ldots, n$ (Hwang & Yoon 1981). The profit or benefit criteria are those you want to maximize, and the cost criteria are those whose values should be minimized. The parameters a_j^+ and a_j^- represent the value of the j_{th} criterion of PIS and NIS, respectively (Tiwar & Kumar 2021).

$$PIS = \left\{a_1^+; a_2^+; \cdots ; a_n^+\right\} = \left\{\left(max_i W_{ij} \mid j \in J^+\right), \left(min_i W_{ij} \mid j \in J^-\right)\right\} \tag{14}$$

$$NIS = \left\{a_1^-; a_2^-; \cdots ; a_n^-\right\} = \left\{\left(min_i W_{ij} \mid j \in J^+\right), \left(max_i W_{ij} \mid j \in J^-\right)\right\} \tag{15}$$

Then, the Euclidean distance between each alternative and the PIS (D_i^+) and the NIS (D_i^-) is calculated, through Equations 16 and 17, where $j = 1, 2, 3, \ldots, m$ (Tiwar & Kumar 2021).

$$D_i^+ = \sqrt{\left(W_{ij} - a_j^+\right)^2} \tag{16}$$

$$D_i^- = \sqrt{\left(W_{ij} - a_j^-\right)^2} \tag{17}$$

Finally, the proximity index ξ_i is calculated, using Equation 18, where $i = 1, 2, 3, \ldots, n$. In this way, it is possible to rank the alternatives in descending order of the value of ξ_i.

$$\xi_i = \frac{D_i^-}{D_i^+ - D_i^-} \tag{18}$$

4 MATERIALS AND METHODS

According to Lakatos & Marconi (2009), this research can be considered a construct and quantitative, as it seeks to optimize the ranking of students who graduated from CAP, in the decision-making process of nominating new instructors, expressing the results and procedures through quantitative variables.

As for the technique, as argued by Gil (2017), this research can be classified as bibliographical, since a theoretical review related to the state of the art of the AHP and TOPSIS methods were necessary. This is also research that deals with a case study that deals with the selection process of new instructors in the context of the Brazilian Air Force (Da Silva et al. 2022).

Yin (2005) stresses that case studies are usually the best strategy when questioning the "how" and "why"; when circumstances are beyond your control, and the emphasis is on studying social dynamics and related phenomena. The focus in phenomenology is addressed through the example of the EAOAR instructor selection problem. EAOAR provided the anonymized data of 67 Student Officers from the CAP Class 1-2021, referring to their performance in the six current decision criteria. The organization provided these data through a Term of Consent for the Use of Data (TCUD). As suggested by De Almeida (2013), the framework of this decision-making process followed three phases and twelve steps, which are explained below.

In the preliminary phase, the decision-maker in this process was characterized, who is the Commandant of EAOAR, a Colonel of the Air Force Aviation Officers, who is responsible, among other things, for "imprinting the teaching provided at EAOAR with the doctrinal guidance emanating from the Air Force General Staff (EMAER)" (Brasil 2020). Thus, to appoint new instructors, the decision-maker has a Teaching Advisory (ASENS), "a collegiate body that will be called upon to deliberate on matters related to student Officers and other administrative and academic matters, at the Commandant's discretion" (Brasil 2021).

ASENS is thus composed of the Commandant of the School, plus the Head of the Teaching Division; the Commandant of the Student Corps; the Head of the Administrative Section; the Head of the Governance Office; the Head of the Pedagogical Advisory; and the Head of the Psychopedagogical Advisory. It should be noted that, although assisted by the other actors, the decision to appoint new instructors is the prerogative of the School Commandant.

EAOAR's institutional values underlie the fundamental objective of the decision-making process, which is to indicate new instructors, chosen because they have characteristics aligned with the institution. Briefly, these values are (1) integrity guided by ethics, honesty, and uprightness of character; (2) respect for people, rules, and regulations in force; (3) constant improvement; (4) team spirit; and (5) love of teaching. In addition, there are means-objectives that directly impact the fundamental objectives, and that help to establish six criteria or attributes, against which each student officer (alternative) is evaluated, which represent how much the objectives are achieved (Keeney 1992). Table 4 clarifies these six criteria.

Table 4 – Criteria for nominating Instructors (Da Silva et al. 2022).

Criteria	Description	Goal
MFINC	Final average of the courses taken, ranging from 0.000 to10.000.	Maximize
NOTCC	Grade for the oral presentation of the course completion work, ranging from 0.000 to 10.000.	Maximize
AIOTG	Subjective evaluation of the Instructor Guiding Group Work (IOTG), expressed in a verbal scale, in which: 1- I do not indicate; 2- Neutral; and 3- I Indicate.	Maximize
AOTCC	Advisor's subjective assessment of the course completion work, expressed on a verbal scale, in which: 1- I do not indicate; 2- Neutral; and 3- I Indicate.	Maximize
COHOR	Horizontal concept, in which each student evaluates his peers in the class, expressed in a verbal scale, in which: 1- I do not indicate; 2- Neutral; and 3- Indico. The performance in this criterion is measured by the sum of the evaluations received.	Maximize
AAPSI	Evaluation carried out by the School's Psychopedagogical Advisory, expressed in a verbal scale, in which: 1- I do not indicate; 2- Neutral; and 3- I indicate.	Maximize

In the context of this deterministic decision-making problem, the range of possible actions was defined by a distinct set of options denoted as $A = \{a_1, a_2, a_3, \ldots, a_{67}\}$, which corresponded to the Officer student candidates eligible for nomination. It's worth noting that this set remained constant and unaltered throughout the decision-making process. In addition, all 67 student officers were submitted to the decision-making process, and a final desirable number of nominations was not defined a priori, characterizing a global set of alternatives.

For simplification, this decision problem was not considered a classification problem, because the inclusion [or not] in the class of those indicated to instructor was the prerogative of the Commandant of EAOAR. Then, as suggested by Roy (1996), the type of ranking problem was established (P.γ), since the set of actions was presented to the decision maker, ordered from the best to the worst alternative, and the EAOAR Commandant oversaw classifying [or not] the candidates for the function of instructor. This aspect of the decision-making problem is important as the decision maker wants to know how far [or close] each Student Officer is from PIS and NIS. Thus, the matrix of consequences for the selection of EAOAR instructors was defined, as shown in Table 5, which shows the performance of each Student Officer (Sn) in the decision-making criteria (Cm).

Table 5 – Consequence matrix.

Alternatives		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}
Criteria (Max)	**MFINC**	9,817	9,810	9,807	9,805	9,792	9,779	9,775	9,753	9,746	9,745	9,743	9,738	9,736	9,735
	NOTCC	9,920	9,710	10,000	9,710	10,000	10,000	9,660	10,000	10,000	9,860	9,850	10,000	9,850	10,000
	AIOTG	3	3	3	3	3	3	3	3	3	3	3	3	1	3
	AOTCC	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	COHOR	797	550	739	348	162	235	444	275	241	327	297	238	105	159
	AAPSI	2	2	3	3	2	2	2	2	3	2	2	1	1	2

Alternatives		S_{15}	S_{16}	S_{17}	S_{18}	S_{19}	S_{20}	S_{21}	S_{22}	S_{23}	S_{24}	S_{25}	S_{26}	S_{27}	S_{28}
Criteria (Max)	**MFINC**	9,724	9,721	9,717	9,716	9,711	9,708	9,704	9,702	9,702	9,692	9,691	9,679	9,678	9,676
	NOTCC	9,700	9,820	9,860	9,540	9,880	9,810	9,860	9,620	9,790	9,310	9,930	9,630	9,370	10,000
	AIOTG	2	3	3	3	3	3	3	3	3	3	2	3	3	3
	AOTCC	3	3	3	1	3	3	3	3	1	3	3	2	3	3
	COHOR	188	249	206	102	334	144	138	151	132	144	165	150	144	560
	AAPSI	2	2	2	2	2	3	2	2	2	2	2	2	2	3

Alternatives		S_{29}	S_{30}	S_{31}	S_{32}	S_{33}	S_{34}	S_{35}	S_{36}	S_{37}	S_{38}	S_{39}	S_{40}	S_{41}	S_{42}
Criteria (Max)	**MFINC**	9,670	9,667	9,665	9,662	9,624	9,616	9,613	9,611	9,609	9,609	9,592	9,582	9,573	9,571
	NOTCC	9,860	9,500	9,640	9,760	9,810	9,910	10,000	10,000	9,700	10,000	9,810	9,450	9,540	9,620
	AIOTG	3	3	3	3	3	3	3	3	1	3	3	3	3	3
	AOTCC	3	3	3	3	3	3	3	3	3	2	3	3	3	3
	COHOR	292	430	134	393	110	166	480	327	417	196	167	170	197	313
	AAPSI	3	2	2	2	2	2	2	2	2	2	2	2	3	3

Alternatives		S_{43}	S_{44}	S_{45}	S_{46}	S_{47}	S_{48}	S_{49}	S_{50}	S_{51}	S_{52}	S_{53}	S_{54}	S_{55}	S_{56}
Criteria (Max)	**MFINC**	9,562	9,555	9,552	9,549	9,548	9,538	9,530	9,503	9,478	9,459	9,411	9,401	9,393	9,341
	NOTCC	10,000	9,480	9,490	9,760	9,770	9,880	10,000	10,000	10,000	9,880	9,840	9,810	10,000	10,000
	AIOTG	3	3	3	3	1	2	3	2	3	3	3	3	3	3
	AOTCC	3	3	2	3	1	3	3	3	3	3	2	1	3	2
	COHOR	356	250	168	320	135	138	120	192	319	139	153	153	159	189
	AAPSI	2	2	2	2	2	3	2	3	2	3	2	2	2	2

Alternatives		S_{57}	S_{58}	S_{59}	S_{60}	S_{61}	S_{62}	S_{63}	S_{64}	S_{65}	S_{66}	S_{67}
Criteria (Max)	**MFINC**	9,335	9,319	9,308	9,306	9,262	9,245	9,226	9,218	9,197	9,176	9,101
	NOTCC	9,880	10,000	10,000	10,000	10,000	9,810	9,890	9,820	10,000	9,880	10,000
	AIOTG	3	3	1	1	3	3	3	1	3	3	3
	AOTCC	1	3	2	1	3	1	3	3	2	3	2
	COHOR	117	212	104	98	189	283	147	127	192	195	115
	AAPSI	2	2	2	2	2	3	1	2	3	3	2

Taking as reference the Saaty Fundamental Scale, as shown in Table 2, they were initially asked about "which criterion would be more important, one or the other"? And the next question was: "how much is this criterion more important than the other"? Table 6 presents the pairwise comparisons of the criteria with the preferences of these instructors (DM_i) and the aggregate preferences.

The instructors who advised the Commandant made 15 parity comparisons, according to Equation 5. It was also found that the decision-maker's preference structure incorporates preference and indifference relationships, justifying an additive aggregation model and a compensatory approach. In this way, the modelling of preferences was built using the AHP method. The inter-criteria evaluation was carried out by eliciting the weights using Saaty's Fundamental Scale (Saaty 1980). Geometric mean was used to aggregate the parity comparison matrices to maintain their reciprocity.

Then, the aggregate preference matrix was normalized according to Equation 7. Thus, the priority vector of the criteria was calculated, using Equation 8 and the consistency ratio (CR), using

Equation 1. Table 7 shows the values of the normalized comparison matrix, the priority vector of the criteria and CR < 0.10.

Uncontrolled factors were identified as, possibly, the existence of biases in the subjective evaluations of the IOTG, the OTCC and the COHO. Furthermore, the School may suffer external political pressure to increase or decrease the number of student officers appointed. However, uncontrolled factors were not considered in the scope of this model, for simplification.

In the intra-criterion evaluation, value functions based on the natural scales of the criteria were used, using the normalization of the TOPSIS method. The alternatives were evaluated using the Three Decision Methods (3DM) Software Web application, developed by Bozza et al. (2020). This assessment made it possible to order student officers according to their Euclidean distances in relation to the PIS and NIS. Table 8 shows the results of D_i^+, D_i^- and ξ and the final ranking of Student Officers can be seen in Table 9.

Table 6 – Pairwise comparison matrices.

DM1	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	6	6	6	3	4
NTCC	1/6	1	1	1/6	4	4
IOTG	1/6	1	1	4	4	4
OTCC	1/6	6	1/4	1	1/4	1/4
COHO	1/3	1/4	1/4	4	1	1/7
APSI	1/4	1/4	1/4	4	7	1

DM2	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1/3	1/5	1/5	1/3	1/7
NTCC	3	1	1	1	4	1/5
IOTG	5	1	1	1	4	1/3
OTCC	5	1	1	1	2	1/7
COHO	3	1/4	1/4	1/2	1	1/5
APSI	7	5	3	7	5	1

DM3	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1/5	1/5	1/5	1/5	1/4
NTCC	5	1	1	1	5	3
IOTG	5	1	1	5	1	4
OTCC	5	1	1/5	1	1/5	1/4
COHO	5	1/5	1	5	1	4
APSI	4	1/3	1/4	4	1/4	1

DM4	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1	1/4	1/4	1/2	1/7
NTCC	1	1	1/4	1/4	1/4	1/7
IOTG	4	4	1	1	1	1
OTCC	4	4	1	1	1	1
COHO	2	4	1	1	1	1/4
APSI	7	7	1	1	4	1

DM5	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1/6	1/6	1/6	1	3
NTCC	6	1	1/6	3	5	4
IOTG	6	6	1	5	4	4
OTCC	6	1/3	1/5	1	3	3
COHO	1	1/5	1/4	1/3	1	1
APSI	1/3	1/4	1/4	1/3	1	1

DM6	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1	1	9	9	9
NTCC	1	1	1	9	9	9
IOTG	1	1	1	9	9	9
OTCC	1/9	1/9	1/9	1	9	9
COHO	1/9	1/9	1/9	1/9	1	1
APSI	1/9	1/9	1/9	1/9	1	1

DM7	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	1/9	1/9	1/2	1/7	1/9
NTCC	9	1	1	9	3	1
IOTG	9	1	1	9	5	2
OTCC	2	1/9	1/9	1	1/9	1/9
COHO	7	1/3	1/5	9	1	1
APSI	9	1	1/2	9	1	1

Aggregate preferences	MFDC	NTCC	IOTG	OTCC	COHO	APSI
MFDC	1	0,3333	0,1771	0,2924	0,2877	0,1314
NTCC	3,0000	1	0,6300	1,3104	1,4422	0,3057
IOTG	5,6462	1,5874	1	2,0801	2,7144	0,8736
OTCC	3,4200	0,7631	0,4807	1	0,6057	0,2513
COHO	3,4760	0,6934	0,3684	1,6510	1	0,3684
APSI	7,6117	3,2711	1,1447	3,9791	2,7144	1

Table 7 – Normalized pairwise comparison matrix, priority and consistency ratio.

	MFDC	NTCC	IOTG	OTCC	COHO	APSI	Priority	λ_{Max}	CI	RI	CR
MFDC	0,0414	0,0436	0,0466	0,0284	0,0328	0,0448	0,0396	6,0954	0,0191	1,24	0,0154
NTCC	0,1242	0,1307	0,1657	0,1271	0,1646	0,1043	0,1361				
IOTG	0,2338	0,2075	0,2631	0,2017	0,3097	0,2981	0,2523				
OTCC	0,1416	0,0998	0,1265	0,0970	0,0691	0,0858	0,1033				
COHO	0,1439	0,0907	0,0969	0,1601	0,1141	0,1257	0,1219				
APSI	0,3151	0,4277	0,3012	0,3858	0,3097	0,3413	0,3468				

Table 8 – Relative proximity of PIS and NIS.

	D+	D-	ξ
S1	0.0191	0.0481	0.7156
S2	0.0232	0.0388	0.6257
S3	0.0031	0.0565	0.9481
S4	0.0239	0.0469	0.6622
S5	0.0389	0.0306	0.4409
S6	0.0355	0.0313	0.4685
S7	0.0268	0.0356	0.5701
S8	0.0337	0.0319	0.4857
S9	0.0296	0.0456	0.6064
S10	0.0315	0.0328	0.5100
S11	0.0328	0.0322	0.4957
S12	0.0485	0.0248	0.3389
S37	0.0354	0.0272	0.4345
S38	0.0376	0.0299	0.4427
S39	0.0386	0.0307	0.4425
S40	0.0385	0.0307	0.4434
S41	0.0320	0.0453	0.5861
S42	0.0258	0.0464	0.6428
S43	0.0303	0.0334	0.5245
S44	0.0349	0.0315	0.4745
S45	0.0389	0.0296	0.4324
S46	0.0318	0.0327	0.5066
S47	0.0466	0.0192	0.2923
S48	0.0368	0.0409	0.5265

	D+	D-	ξ
S13	0.0574	0.0092	0.1385
S14	0.0390	0.0306	0.4398
S15	0.0392	0.0243	0.3830
S16	0.0349	0.0315	0.4743
S17	0.0368	0.0310	0.4568
S18	0.0427	0.0290	0.4047
S19	0.0312	0.0329	0.5135
S20	0.0348	0.0450	0.5642
S21	0.0400	0.0305	0.4329
S22	0.0394	0.0306	0.4370
S23	0.0413	0.0291	0.4132
S24	0.0397	0.0305	0.4346
S49	0.0408	0.0305	0.4274
S50	0.0340	0.0411	0.5473
S51	0.0318	0.0326	0.5062
S52	0.0351	0.0450	0.5623
S53	0.0395	0.0295	0.4275
S54	0.0403	0.0292	0.4197
S55	0.0390	0.0306	0.4398
S56	0.0379	0.0298	0.4401
S57	0.0420	0.0290	0.4089
S58	0.0366	0.0310	0.4592
S59	0.0472	0.0197	0.2946
S60	0.0481	0.0192	0.2849

	D+	D-	ξ
S25	0.0402	0.0241	0.3750
S26	0.0397	0.0295	0.4264
S27	0.0397	0.0305	0.4346
S28	0.0126	0.0513	0.8024
S29	0.0269	0.0462	0.6317
S30	0.0274	0.0352	0.5626
S31	0.0402	0.0305	0.4315
S32	0.0288	0.0343	0.5433
S33	0.0413	0.0304	0.4244
S34	0.0387	0.0307	0.4422
S35	0.0255	0.0366	0.5894
S36	0.0315	0.0328	0.5101
S61	0.0376	0.0308	0.4504
S62	0.0289	0.0451	0.6097
S63	0.0516	0.0238	0.3160
S64	0.0460	0.0213	0.3163
S65	0.0326	0.0446	0.5778
S66	0.0321	0.0453	0.5853
S67	0.0413	0.0294	0.4158

Table 9 – Final ranking of Student Officers.

	Alternative	ξ		**Alternative**	ξ		**Alternative**	ξ
1º	S3	0.9481	**24º**	S10	0.5100	**47º**	S21	0.4329
2º	S28	0.8024	**25º**	S46	0.5066	**48º**	S45	0.4324
3º	S1	0.7156	**26º**	S51	0,5062	**49º**	S31	0.4315
4º	S4	0.6622	**27º**	S11	0,4957	**50º**	S53	0.4275
5º	S42	0.6428	**28º**	S8	0.4857	**51º**	S49	0.4274
6º	S29	0.6317	**29º**	S44	0.4745	**52º**	S26	0.4264
7º	S2	0.6257	**30º**	S16	0.4743	**53º**	S33	0.4244
8º	S62	0.6097	**31º**	S6	0.4685	**54º**	S54	0.4197
9º	S9	0.6064	**32º**	S58	0.4592	**55º**	S67	0.4158
10º	S35	0.5894	**33º**	S17	0.4568	**56º**	S23	0.4132
11º	S41	0.5861	**34º**	S61	0.4504	**57º**	S57	0.4089
12º	S66	0.5853	**35º**	S40	0.4434	**58º**	S18	0.4047
13º	S65	0.5778	**36º**	S38	0.4427	**59º**	S15	0.3830
14º	S7	0.5701	**37º**	S39	0.4425	**60º**	S25	0.3750
15º	S20	0.5642	**38º**	S34	0.4422	**61º**	S12	0.3389
16º	S30	0.5626	**39º**	S5	0.4409	**62º**	S64	0.3163
17º	S52	0.5623	**40º**	S56	0.4401	**63º**	S63	0.3160
18º	S50	0.5473	**41º**	S14	0.4398	**64º**	S59	0.2946
19º	S32	0.5433	**42º**	S55	0.4398	**65º**	S47	0.2923
20º	S48	0.5265	**43º**	S22	0.4370	**66º**	S60	0.2849
21º	S43	0.5245	**44º**	S27	0.4346	**67º**	S13	0.1385
22º	S19	0.5135	**45º**	S24	0.4346			
23º	S36	0.5101	**46º**	S37	0.4345			

Once the AHP-TOPSIS method was used to rank the available alternatives, the resulting order was kept confidential and subsequently compared to the decision-maker's actual choices. This was done to assess the robustness between the ranking and the ultimate decisions made (Da Silva et al. 2022). This ranking was presented to the EAOAR Commandant, and later compared with the actual nominations of the candidates, as can be seen in Table 10.

The analysis of results was carried out using the R programming language to calculate the statistics of the application of the hybrid AHP-TOPSIS method (R Core Team 2022). It is observed that, when only the students' results are considered, there is no significant difference between the highest and lowest grade. However, after running the hybrid AHP-TOPSIS method, a great gap between these results is observed (Max-Min), although the students are not the same in both cases.

Then, the Shapiro-Wilk normality test was performed, assuming as H_0: Gaussian distribution of data, if $p-value > 0.05$; and H_1: data that does not follow a normal distribution, if $p-value \leq 0.05$. The values of $W = 0.93376$ and $p-value = 0.001482$ led to the rejection of H_0 and the acceptance of the non-normality of the data distribution.

Table 10 – Appointed and not appointed by the EAOAR Commandant.

	Alternative	Appointed?		Alternative	Appointed?		Alternative	Appointed?
1º	S3	Yes	**24º**	S10	Yes	**47º**	S21	No
2º	S28	Yes	**25º**	S46	Yes	**48º**	S45	Yes
3º	S1	Yes	**26º**	S51	Yes	**49º**	S31	Yes
4º	S4	Yes	**27º**	S11	Yes	**50º**	S53	Yes
5º	S42	Yes	**28º**	S8	No	**51º**	S49	Yes
6º	S29	Yes	**29º**	S44	Yes	**52º**	S26	No
7º	S2	Yes	**30º**	S16	Yes	**53º**	S33	Yes
8º	S62	Yes	**31º**	S6	Yes	**54º**	S54	Yes
9º	S9	Yes	**32º**	S58	Yes	**55º**	S67	Yes
10º	S35	No	**33º**	S17	Yes	**56º**	S23	Yes
11º	S41	Yes	**34º**	S61	Yes	**57º**	S57	No
12º	S66	Yes	**35º**	S40	Yes	**58º**	S18	No
13º	S65	Yes	**36º**	S38	Yes	**59º**	S15	Yes
14º	S7	Yes	**37º**	S39	Yes	**60º**	S25	Yes
15º	S20	Yes	**38º**	S34	Yes	**61º**	S12	Yes
16º	S30	Yes	**39º**	S5	Yes	**62º**	S64	No
17º	S52	Yes	**40º**	S56	Yes	**63º**	S63	No
18º	S50	Yes	**41º**	S14	Yes	**64º**	S59	No
19º	S32	No	**42º**	S55	Yes	**65º**	S47	No
20º	S48	Yes	**43º**	S22	Yes	**66º**	S60	No
21º	S43	No	**44º**	S27	No	**67º**	S13	No
22º	S19	Yes	**45º**	S24	Yes			
23º	S36	Yes	**46º**	S37	Yes			

This analysis led to the use of the Wilcoxon paired non-parametric test for data analysis, assuming that H_0 : the median difference in grades = 0, if $p-value > 0.05$; and H_1 : the median difference of grades $\neq 0$, if $p-value \leq 0.05$. The values of $V = 2278$ and $p-value = 1,145x10^{-12}$ allowed us to conclude that the students' grade after applying the AHP-TOPSIS method was statistically lower than the grade before its application, and that there was a significant difference in the ordering of the alternatives, which were previously ranked only based on the MFINC, but were later ranked with the AHP-TOPSIS method. Figures 2 and 3 show the boxplot of the data before and after the methods, respectively.

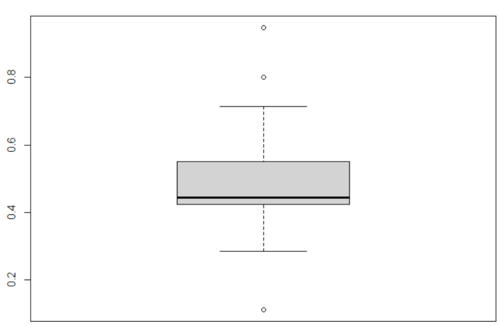

Figure 2 – Boxplot Before AHP-TOPSIS.

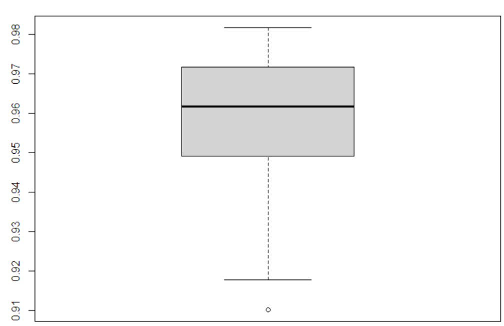

Figure 3 – Boxplot after AHP-TOPSIS.

5 ANALYSIS OF RESULTS

Table 9 shows the results of the new TOPSIS ordering. Based on the 27th individual (S11), with a coefficient equal to 0.4957, it is possible to draw a threshold profile, above which the alternatives are closer to PIS and farther from NIS. On the other hand, the alternatives ordered below the individual S11 are more distant from the PIS and closer to the NIS.

Table 10 shows that 88.89% of the 27 candidates above the S11 individual were appointed to the instructor role. This percentage could be higher, because the S35 candidate was rejected, although ranked in 10th place, because factors external to the proposed model influenced the Commandant in his decision. In addition, only 70.00% of the remaining candidates received nomination from the EAOAR Commandant. It is also possible to observe that none of the last 6 candidates received nominations and that the majority of those not nominated composed the 4th quartile, that is, closer to the NIS.

The results of the study showed that candidates who were closest to PIS were named more frequently, while those closest to NIS received more rejections. This indicates that the use of a hybrid approach combining the AHP and TOPSIS methods was successful in classifying the alternatives, which in turn facilitated a more impartial and comprehensive evaluation of the candidates.

For example, when comparing Tables 5 and 10, it is noticed that the last candidate of the ranking obtained the 13th highest final average of the CAP and, if the decision-making process was conducted in a skewed way on this criterion, possibly the candidate S13 would have been indicated. In addition, it is observed that the candidate S66, with the second worst final average of the CAP, was ranked as 12th by the TOPSIS method, valuing its overall evaluation in all decision criteria.

In this sense, the objective of this work was achieved, considering that it was possible to answer how an alternative ordering model allow to improve the process of appointing new EAOAR instructors, ordering the 67 students of the CAP 1/2021 class, candidates for instructor appointment, in the period between April and July 2021.

6 CONCLUSIONS

This new approach to the problem may give greater robustness to the analyzes, in addition to providing greater security to the decision-maker. Results revealed that candidates closest to the PIS received more favourable indications, while those closer to the NIS received more rejections. The AHP and TOPSIS hybrid approach successfully ranked candidates and accelerated the process, making it more reliable and faster. It is understood that the approach of this work can be improved, in the sense of ratifying the objectives and criteria involved in the decision-making problem, through a multimethodological approach, including completely the VFT method proposed by Keeney (1992).

In addition, in human resources management of the Brazilian Navy and the Brazilian Army, the hybrid approach AHP-TOPSIS can be especially useful to evaluate candidates for missions abroad, for example those promoted by the United Nations (UN). This methodology can help the High Command of these institutions to decide on which candidates to designate for such missions, ranking the alternatives according to their suitability to work, based on a set of predetermined criteria.

This hybrid approach can also be used to assess the performance of employees of any organization, civilian or military. Leaders can use AHP and TOPSIS methods in combination to identify areas of employee focus and job improvement opportunities. This methodology can also help identify training and personnel development needs. Thus, this approach is a useful tool for data-based decision making, contributing to the reduction of prejudices and subjectivity in the evaluation process, improving the overall effectiveness of the hiring and performance evaluation processes.

Finally, it is important to highlight that this work focuses on the hybrid application of ranking methods, assuming the limitation of the final classification of candidates, prerogative of the EAOAR Commandant. However, as a suggestion for future work, other studies may consider the classification problem and apply, for example, the methods of the ELECTRE family.

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