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TECHNOLOGICAL INFORMATION

Integrating TOPSIS and three-dimensional importance-performance analysis to formulate the career competitiveness evaluation model under the MAES

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ABSTRACT. Taiwan's declining birth rate and the lack of personnel in the national army have worsened. In particular, the loss of human resources caused by the lack of career competitiveness among national army officers has been increasing daily. Effective career competitiveness not only aligns personal interests with job roles but also enhances self-confidence and increases workplace value. The professional competitiveness of military officers depends on the nurturing of the Military Academy Education System (MAES), which involves the comprehensive consideration and evaluation of individual performance such as university education (UE), sport and combat ability (SCA), and military skill (MS); it is a complex multiple attribute decision making (MADM) problem. However, the current method fails to effectively consider individual attributes, which may result in cadets being assigned to unsuitable units or positions, leading them to consider retirement and thereby weakening national defense capabilities. To solve this problem, this research integrated the technique for order preference by similarity to an ideal solution (TOPSIS) and three-dimensional importance-performance analysis method to propose a novel three-dimensional TOPSIS (3D-TOPSIS) model, aimed at improving the evaluation process of cadets' career competitiveness. The results demonstrate that this model accurately assesses cadets' attributes and distribution, providing valuable insights for personnel assignments and the allocation of educational resources.

Keywords: cadets; career competitiveness; TOPSIS; importance-performance analysis; three-dimensional importance-performance analysis.

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Introduction

Assigning military personnel to appropriate positions based on their career competitiveness has a significant impact on a nation's military capability. Taiwan's declining birth rate and the lack of personnel in the national army have worsened. In particular, the loss of human resources caused by the lack of career competitiveness among national army officers has been increasing daily. Career competitiveness development refers to the process of personal work and growth, which affects the country's national talent cultivation plan and resource allocation (Soylu et al., 2021; Jiang et al., 2020; Hsieh et al., 2019). Cadets of ROC Military Academy must undergo the military academy education system (MAES) for four years. Upon graduation, they are selected or assigned to various units of the national army to serve as indispensable and important officers and cadres, serve at least ten years in their professional career, and gradually work in units of different levels. Jobs are classified into command positions, staff positions, and education positions; they may experience various units and fields in their military careers. It is worth discussing topics such as adapting to changes in the overall environment, achieving the needs and satisfaction of career development, and cultivating comprehensive abilities such as self-interest, self-learning, and self-efficacy (Burnette et al., 2020). An individual's excellent career competitiveness not only combines personal interests and positions but also helps improve their level of educational knowledge, fully demonstrate self-confidence, and recognize their self-worth and role in the workplace (Piotrowska, 2019).

Taiwan is presently facing a treacherous and volatile international situation, increasing military threats from enemy countries, the impact of the COVID-19 epidemic on the overall operation of the army, and natural disasters caused by an extremely abnormal climate (Ministry of National Defense, 2021). How can the ROC Military Academy cadets maintain a competitive advantage in this uncertain environment? MAES plays a key role and takes on an inevitable responsibility and mission to cultivate superior talents. Therefore, officers nurturing education affect cadets' future career development hugely (Lin et al., 2020). Unlike general universities, and apart from university education (UE), cadets in military academies regularly undergo training and testing in sports and combat ability (SCA) after class (Precious & Lindsay, 2019; Davies et al., 2016). They also receive rigorous military skills (MS) training during winter and summer vacations (Military Academy, 2022) to prepare for various challenges (Mitchell et al., 2016; Chen et al., 2015). It is evident that MAES encompasses UE, SCA, and MS, all aimed at preparing cadets to be highly competitive in the workplace, which represents a multiple attribute decision-making (MADM) problem.

Traditionally, military cadets' assignment has been implemented using an artificial subjective weighting method to calculate the grade point average (GPA), the method is purely computational and easy to understand. However, it cannot simultaneously take the performance of UE, SCA, and MS into account. It can also only evaluate the competitiveness of personnel with a single aspect, which may cause cadets to be unfitting for the unit and position, giving them the idea of retiring, which will result in a loss of national defense combat power. Therefore, cadets should be assigned to appropriate positions based on their performance in UE, SCA, and MS from a multi-dimensional perspective. To address the challenges associated with MADM, a systematic approach can be employed to explore the issues at hand. Commonly used methods include entropy (Zhou et al., 2020; Chen & Chang, 2024), technique for order of preference by similarity to ideal solution (TOPSIS) (Keikha, 2022; Chung et al., 2023), analytic hierarchy process (AHP) (Huang et al., 2022; Chang et al., 2015), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) (Mishra et al., 2022; Wen et al., 2020), combined compromise solution (CoCoSo) method (Chang, 2023), and data envelopment analysis (DEA) (Liu et al., 2020; Chang et al., 2024), among others.

Among these methods, TOPSIS can efficiently identify the solution closest to the ideal solution while simultaneously being farthest from the negative ideal, making it highly suitable for problems requiring the balancing of multiple attributes. It has been widely applied to various research topics. For example, Abdul and Wenqi (2022) employed the fuzzy TOPSIS method to evaluate appropriate communication technologies for smart grids; Awodi et al. (2023), applied it for nuclear decommissioning risk management; and Rafiei-Sardooi et al. (2021), integrated TOPSIS with machine learning to assess urban flood risk. Furthermore, based on the concept of importance-performance analysis (IPA) (Wen et al., 2021), it allows for the simultaneous consideration of multiple dimensions, offering a more comprehensive and precise evaluation of complex problems, overcoming the limitations of traditional one-dimensional assessment. For instance, Lai and Hitchcock (2016) used 3D IPA to develop a new service quality measurement model. Therefore, we employ the cadets of military academies belonging to the largest main force of the national army as a case study. We integrated the technique for order preference by similarity to an ideal solution (TOPSIS) and three-dimensional importance-performance analysis (3D IPA) methods to propose a novel 3D-TOPSIS evaluation model to explore the actual attributes and distribution of cadets' career competitiveness, and according to the attribute of career competitiveness, develop a personnel assignment strategy to make an effective allocation of educational resources.

This research is structured as follows. Section "Literature review" briefly introduces the TOPSIS method and the 3D IPA method, while Section "Methodology" details the research model and the research design process. In Section "Case study", the research objects, TOPSIS Analysis, and 3D IPA are described. This section also discusses the analysis results. Finally, conclusions are presented in last Section.

Literature review

TOPSIS method

Hwang and Yoon (1981) proposed the TOPSIS approach to process the related issues of multi-criteria decision-making (MCDM) and multiple attribute decision making (MADM) issues. The concept of the TOPSIS approach is that the best alternative should have the longest distance from the negative ideal solution and the shortest distance from the positive ideal solution (Chodha et al., 2022; Iqbal et al., 2021). In other words, a positive ideal solution means the value of the alternatives with the largest benefit or the smallest cost; otherwise, the value with the smallest benefit or the largest cost is the negative ideal solution. Assigning personnel to appropriate units and positions based on the attributes of cadets' career competitiveness is an MADM problem. The TOPSIS approach has been widely used to solve many MADM issues (Mondal et al., 2021;

Keikha, 2022; Wang et al., 2022). It can be used to evaluate a decision matrix, and the process of implementation is presented in several steps as follows:

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & x_{2n} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & x_{in} \\ x_{m1} & x_{m2} & \cdots & x_{mj} & x_{mn} \end{bmatrix} \quad (1)$$

where x_{ij} is the value of the j^{th} criterion of the i^{th} alternative.

Step 1: Compute the normalized evaluation matrix. The normalized value r_{ij} is computed as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad j = 1, 2, \dots, n; \quad i = 1, 2, \dots, m \quad (2)$$

Step 2: Determine the negative ideal solution A^- and the positive ideal solution A^+.

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} = \left\{\left(\min_j v_{ij} \mid i \in J\right), \left(\max_j v_{ij} \mid i \in J'\right)\right\}, \quad (3)$$

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} = \left\{\left(\max_j v_{ij} \mid i \in J\right), \left(\min_j v_{ij} \mid i \in J'\right)\right\}, \quad (4)$$

where J' is associated with the cost criterion, and J is associated with the benefit criterion. The larger the index value of the benefit criterion, the higher the performance; the smaller the index value of the cost criterion, the higher the performance.

Step 3: Compute the separation measures. Use the n-criterion Euclidean distance to compute the separation measures. The separation of the negative ideal solution and the positive ideal solution for each alternative are measured as D_i^- and D_i^+, respectively:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad i = 1, 2, \dots, m \quad (5)$$

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, \quad i = 1, 2, \dots, m \quad (6)$$

Step 4: Compute the relative closeness to the ideal solution of each alternative. The relative closeness of the i^{th} alternative to positive ideal solution A^+ is defined as.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (7)$$

where $0 \le C_i \le 1$, and $i = 1, 2, \dots, m$. When the C_i value is closer to 1, the solution is closer to the positive ideal solution.

Step 5: Sort the preference order. Alternatives are sorted in descending order of C_i. Arrange the pros and cons of alternatives according to the C_i value. The higher the C_i value, the higher the preference for the alternative.

Three-dimensional importance-performance analysis method

Based on the conception of importance-performance analysis (IPA) (Martilla & James, 1977) and the three-factor theory (Kano et al., 1984), Lai and Hitchcock (2016) proposed the new concept of three-dimensional importance-performance analysis, referred to as 3D IPA, which extends the traditional two-dimensional graphics (X-axis, Y-axis) grid to a 3D graphics (X-axis, Y-axis, Z-axis). It was further used to measure the importance of multi-dimensional features, through which a new research questionnaire was developed. The 3D IPA method can be used to represent the performance of the three dimensions of UE, SCA, and MS to solve the shortcomings of the traditional simple additive weighting method. The graphics was divided into eight quadrants according to the arithmetic average of each dimension. Each quadrant had its own attribute characteristics, as shown in Figure 1. The classification description is as follows.

(1) Quadrant I (X-axis > M; Y-axis > M; Z-axis > M): The overall performance of this individual attribute on the X-axis, Y-axis, and Z-axis is outstanding, indicating that such individuals have excellent talents and competitiveness. They have the best competitive advantage in the organization or team.

(2) Quadrant II (X-axis > M; Y-axis > M; Z-axis < M): This individual attribute has higher performance on the X-axis and Y-axis but lower performance on the Z-axis. Managers may invest in educational resources to strengthen the Z-axis capabilities of such individuals.
(3) Quadrant III (X-axis > M; Y-axis < M; Z-axis > M): This individual attribute has higher performance on the X-axis and Z-axis but lower performance on the Y-axis. Managers may invest in educational resources to strengthen the Y-axis capabilities of such individuals.
(4) Quadrant IV (X-axis > M; Y-axis < M; Z-axis < M): This individual attribute only has higher performance on the X-axis and lower performance on the Y-axis and Z-axis. Managers should make good use of the X-axis expertise and talents of such individuals.
(5) Quadrant V (X-axis < M; Y-axis > M; Z-axis > M): This individual attribute has low performance on the X-axis and high performance on the Y-axis and Z-axis. Managers may invest in educational resources to strengthen the X-axis capabilities of such individuals.
(6) Quadrant VI (X-axis < M; Y-axis > M; Z-axis < M): This individual attribute only has higher performance on the Y-axis and lower performance on the X-axis and Z-axis. Managers should make good use of the Y-axis expertise and talents of such individuals.
(7) Quadrant VII (X-axis < M; Y-axis < M; Z-axis > M): This individual attribute only has high performance on the Z-axis and low performance on the X-axis and Y-axis. Managers should make good use of the Z-axis expertise and talents of such individuals.
(8) Quadrant VIII (X-axis < M; Y-axis < M; Z-axis < M): The overall performance of this individual attribute X-axis, Y-axis, and Z-axis is a disadvantage, indicating that the individuals do not have any competitive advantage, which may cause a burden to the organization or team. Managers should carefully consider and evaluate important decisions (e.g., resource allocation and cultivation training).

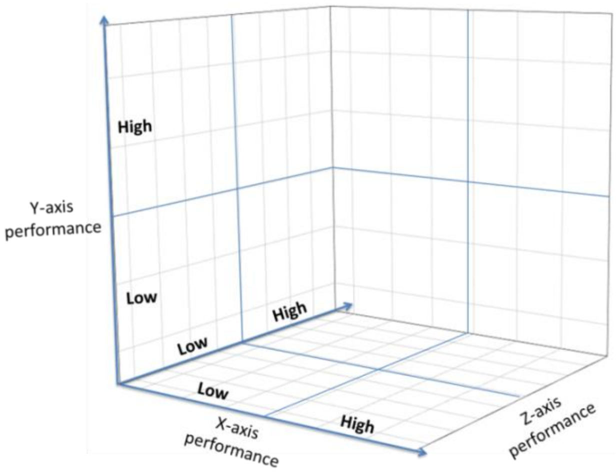

Figure 1. 3D IPA model.

Methodology

Research model

Military cadets are assigned to appropriate units and positions, which can exhibit excellent career competitiveness that combines personal interests with positions, improves continuous learning ability, and shows self-confidence. As a result, they recognize self-worth and their role in the workplace, further improving organizational performance. In the national army, every unit and position has a different attribute. Assigning the best members involves simultaneously considering the degree of UE, SCA, and MS. However, the traditional artificial subjective weighting used to assign military cadets can only handle overall GPA upon graduation but cannot consider other measurement indicators simultaneously. Therefore, this research integrated the TOPSIS and 3D IPA methods to improve the evaluation process in the decision-making problem of military personnel assignment. The TOPSIS method objectively handles quantitative data for the cadets' UE, SCA, and MS scores, and the eight quadrants of the three-dimensional map provide a reference for the allocation of educational resources. The three dimensions correspond to X, Y, and Z as indicators, the X-axis corresponds to TOPSIS-UE (T-UE), the Y-axis corresponds to TOPSIS-SCA (T-SCA), and the Z-axis corresponds to TOPSIS-MS (T-MS). This research separates the attributes of the X, Y, and Z axes into eight quadrants by the arithmetic average. The details are as follows: Quadrant I (T-UE High, T-SCA High, T-MS High), Quadrant II (T-UE High, T-SCA High, T-MS Low), Quadrant III (T-UE High, T-SCA Low, T-MS High), Quadrant IV (T-UE High, T-SCA Low, T-MS Low), Quadrant V (T-UE Low, T-SCA High, T-MS High), Quadrant VI (T-UE Low, T-SCA High, T-MS Low), Quadrant VII (T-UE Low, T-SCA Low, T-MS High), and Quadrant VIII (T-UE Low, T-SCA Low, T-MS Low), shown in Figure 2 and Table 1.

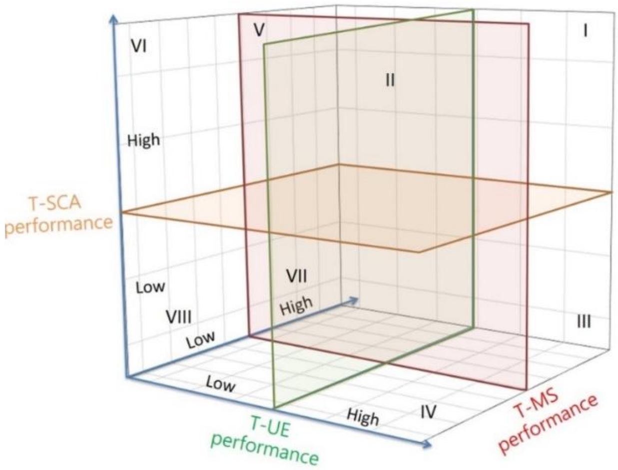

Figure 2. 3D-TOPSIS method.

Table 1. Definition of 3D-TOPSIS graphics and eight quadrants

Quadrant	T-UE performance	T-SCA performance	T-MS performance
I	High	High	High
II	High	High	Low
III	High	Low	High
IV	High	Low	Low
V	Low	High	High
VI	Low	High	Low
VII	Low	Low	High
VIII	Low	Low	Low

Research Design

The implementation steps of the proposed method integrating the TOPSIS and 3D IPA methods are shown in Figure 3:

Step 1: Collect UE, SCA, and MS data for cadets.

This research used cadets' overall GPA (including UE, SCA, and MS scores) upon graduation from Taiwan's military academy as a secondary data source to validate the research model and the original data is presented in Eq. (1).

Step 2: Evaluate the normalized evaluation matrix.

Use Eq. (2) to compute the normalized value of the UE score, SCA score, MS score, and GPA.

Step 3: Determine the positive ideal solution and the negative ideal solution.

Eqs. (3) and (4) were used to calculate the positive and negative ideal solutions.

Step 4: Evaluate the separation measures and relative closeness to the ideal solution.

Eqs. (5), (6), and (7) were used to compute the separation measures and relative closeness to the ideal solution. Among them, UE represents the X-axis, SCA represents the Y-axis, and MS represents the Z-axis.

Step 5: Construct the 3D graphics.

We took the relative closeness values of T-UE, T-SCA, and T-MS, implementing data analysis and evaluation through research models to present the actual situation of cadets' career competitiveness and the distribution of personnel.

Step 6: Rank the cadets and provide a reference for personnel assignment and education.

According to the actual attributes and distribution of cadets' career competitiveness, develop a strategy for personnel assignment and education to effectively use resources. Findings can be provided to grassroots units, military education units, special units, and military academies.

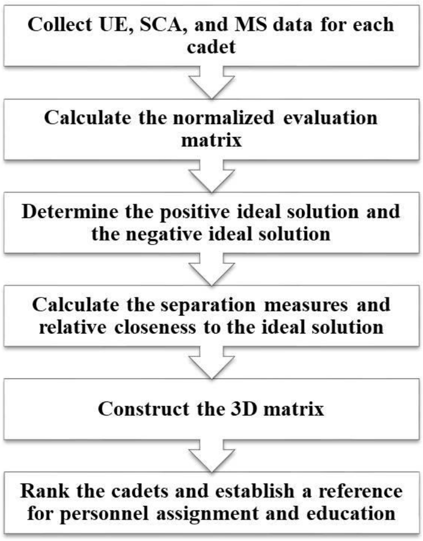

Figure 3. Flowchart for the proposed novel career competitiveness evaluation method.

Case study

Overview

It is a complex MADM problem to assign personnel to appropriate units and positions based on the attributes of cadets' career competitiveness, which involves many evaluations of individual abilities. An appropriate career competitiveness evaluation model under the MAES facilitates the judicious placement of personnel, ensuring optimal alignment with their capabilities and assigning them to positions that maximize their self-efficacy. However, the current practice of assigning military cadets relies on a subjective weighted calculation of the GPA. The GPA, constituting 100% of the evaluation, is comprised of three components: UE, accounting for 60%; SCA, accounting for 10%; and MS, accounting for 30%. The potential biases introduced in assessing personnel competitiveness pose a significant risk of misaligning individuals with their ideal positions, potentially resulting in the premature retirement of valuable human resources in national defense.

To address the aforementioned gaps in personnel assignment, this study proposed a novel approach by integrating the TOPSIS and 3D IPA methods. The framework introduced a 3D-TOPSIS evaluation model tailored to the attributes of occupational competitiveness. Subsequently, strategic staffing recommendations were formulated based on the outcomes of this model. The empirical application of this methodology was demonstrated through a case study conducted at a military academy located in Taiwan. The study collected and anonymized the GPAs of 18 cadets, utilizing code names to represent individual cases. The original GPA scores of the 18 cadets are presented in Table 2.

Table 2. The original scores of GPA for 18 cadets

Cadets	UE score	SCA score	MS score
C1	88.11	78.50	79.99
C2	85.34	80.50	83.82
C3	84.88	81.05	83.57
C4	83.75	79.53	85.27
C5	82.51	79.40	84.76
C6	81.55	78.66	83.98
C7	82.56	79.21	80.35
C8	80.49	79.70	83.51
C9	79.72	81.40	83.01
C10	79.72	78.84	83.40
C11	81.03	76.68	80.77
C12	81.11	79.24	79.15
C13	78.98	80.68	82.62
C14	79.77	80.06	80.21
C15	78.59	81.84	81.25
C16	78.62	82.08	80.03
C17	78.28	78.91	79.73
C18	78.00	78.66	77.34

Solution by the traditional weighting method

MAES helps cultivate cadets' career competitiveness through diversified educational courses and training channels. However, the current method of assigning cadets to units and positions is determined by their respective overall GPA upon graduation, and members with a higher GPA are prioritized. The traditional method of weighting the GPA for the 18 cadets is shown in Table 3.

Table 3. The traditional weighting method of GPA for 18 cadets

Cadets	UE score	SCA score	MS score	GPA	Ranking
C1	88.11	78.50	79.99	84.71	1
C2	85.34	80.50	83.82	84.40	2
C3	84.88	81.05	83.57	84.10	3
C4	83.75	79.53	85.27	83.78	4
C5	82.51	79.40	84.76	82.87	5
C6	81.55	78.66	83.98	81.99	6
C7	82.56	79.21	80.35	81.56	7
C8	80.49	79.70	83.51	81.32	8
C9	79.72	81.40	83.01	80.88	9
C10	79.72	78.84	83.40	80.74	10
C11	81.03	76.68	80.77	80.52	11
C12	81.11	79.24	79.15	80.34	12
C13	78.98	80.68	82.62	80.24	13
C14	79.77	80.06	80.21	79.93	14
C15	78.59	81.84	81.25	79.71	15
C16	78.62	82.08	80.03	79.39	16
C17	78.28	78.91	79.73	78.78	17
C18	78.00	78.66	77.34	77.87	18

Solution by the TOPSIS method

The TOPSIS method is recognized as a prominent technique and is extensively employed in resolving MCDM problems. This methodology seeks to identify a solution that simultaneously minimizes the distance from the positive ideal solution and maximizes the distance from the negative ideal solution. According to Table 2, this research adopted Eqs. (2), (3), and (4) to calculate the values of UE, SCA, and the MS normalized evaluation matrix of the 18 cadets to improve the efficiency of calculation, confirm the negative ideal solution (A^-) and positive ideal solution (A^+) could help to compare the performance of the cadets with the best and worst cases, and then evaluate the advantages and disadvantages of the cadets.

Table 4. The normalized evaluation matrix for 18 cadets

Cadets	UE score	SCA score	MS score
C1	0.255	0.232	0.230
C2	0.247	0.238	0.241
C3	0.246	0.240	0.241
C4	0.243	0.235	0.246
C5	0.239	0.235	0.244
C6	0.236	0.233	0.242
C7	0.239	0.234	0.231
C8	0.233	0.236	0.240
C9	0.231	0.241	0.239
C10	0.231	0.233	0.240
C11	0.235	0.227	0.233
C12	0.235	0.234	0.228
C13	0.229	0.239	0.238
C14	0.231	0.237	0.231
C15	0.228	0.242	0.234
C16	0.228	0.243	0.230
C17	0.227	0.233	0.230
C18	0.226	0.233	0.223
A^+	0.255	0.243	0.246
A^-	0.226	0.227	0.223

According to the results of Table 4, we adopted Eqs. (5), (6), and (7) to calculate the evaluation values of the 18 cadets as well as the relative closeness values of the positive ideal solution (D_i^+) and the relative closeness values of the negative ideal solution (D_i^-). The closer the value of C_i was to 1, the better the performance of the cadet, and who could be listed as a candidate for priority consideration. The separation measures and relative closeness to the ideal solution of the 18 cadets are detailed in Table 5. The separation measures and the relative closeness to the ideal solution for the UE score, SCA score, and MS score of the 18 cadets are shown in Table 6.

Table 5. The separation measures and the relative closeness to the ideal solution for 18 cadets

Cadets	D_i^+	D_i^-	C_i
C1	0.019	0.031	0.624
C2	0.010	0.030	0.749
C3	0.011	0.030	0.730
C4	0.015	0.029	0.667
C5	0.018	0.026	0.592
C6	0.022	0.022	0.507
C7	0.023	0.017	0.431
C8	0.024	0.021	0.471
C9	0.025	0.022	0.466
C10	0.027	0.019	0.419
C11	0.029	0.013	0.313
C12	0.028	0.013	0.314
C13	0.028	0.019	0.411
C14	0.029	0.014	0.326
C15	0.030	0.019	0.389
C16	0.031	0.018	0.362
C17	0.034	0.010	0.220
C18	0.039	0.006	0.132

Table 6. The separation measures and the relative closeness to the ideal solution for UE, SCA, and MS scores of 18 cadets

Cadets	UE score			SCA score			MS score		
	D_i^+	D_i^-	C_i	D_i^+	D_i^-	C_i	D_i^+	D_i^-	C_i
C1	0.000	0.029	1.000	0.011	0.005	0.337	0.015	0.008	0.334
C2	0.008	0.021	0.726	0.005	0.011	0.707	0.004	0.019	0.817
C3	0.009	0.020	0.681	0.003	0.013	0.809	0.005	0.018	0.786
C4	0.013	0.017	0.569	0.008	0.008	0.528	0.000	0.023	1.000
C5	0.016	0.013	0.446	0.008	0.008	0.504	0.001	0.021	0.936
C6	0.019	0.010	0.351	0.010	0.006	0.367	0.004	0.019	0.837
C7	0.016	0.013	0.451	0.008	0.007	0.469	0.014	0.009	0.380
C8	0.022	0.007	0.246	0.007	0.009	0.559	0.005	0.018	0.778
C9	0.024	0.005	0.170	0.002	0.014	0.874	0.007	0.016	0.715
C10	0.024	0.005	0.170	0.010	0.006	0.400	0.005	0.017	0.764
C11	0.021	0.009	0.300	0.016	0.000	0.000	0.013	0.010	0.433
C12	0.020	0.009	0.308	0.008	0.008	0.474	0.018	0.005	0.228
C13	0.026	0.003	0.097	0.004	0.012	0.741	0.008	0.015	0.666
C14	0.024	0.005	0.175	0.006	0.010	0.626	0.015	0.008	0.362
C15	0.028	0.002	0.058	0.001	0.015	0.956	0.012	0.011	0.493
C16	0.028	0.002	0.061	0.000	0.016	1.000	0.015	0.008	0.339
C17	0.028	0.001	0.028	0.009	0.007	0.413	0.016	0.007	0.301
C18	0.029	0.000	0.000	0.010	0.006	0.367	0.023	0.000	0.000

Solution by the Three-dimensional TOPSIS method

To properly solve the problem of personnel assignment, this research integrated the TOPSIS and 3D IPA methods to implement the optimal sorting of cadets and provide suggestions for future educational resource allocation. This research extended the concept of three-dimensional IPA. The T-UE, T-SCA, and T-MS scores of the 18 cadets were used as the evaluation indicators of the X-axis, Y-axis, and Z-axis, respectively. The cadets' average T-UE, T-SCA, and T-MS values were used as the center coordinate of a 3D IPA graphics with eight quadrants. The relative positions of different points in the graphics represented the cadets' differences, as shown in Figure 4 and Table 7. The location of the quadrant to which each cadet belonged is explained as follows.

Quadrant I (T-UE High, T-SCA High, T-MS High): C2 and C3 cadets were in quadrant I. As far as the traditional weighting method is concerned, although their GPA performance was not the best, through the proposed method proposed by this research, their performance was evaluated as excellent overall. It was recommended that they be assigned to senior or special units first, as they would be suitable for all positions.

Quadrant II (T-UE High, T-SCA High, T-MS Low): No cadets were in quadrant II. The attributes of this quadrant applied to the sports staff of senior units and the sports instructors of schools or institutions. However, since there were no suitable cadets, it was recommended to select either C2 or C3.

Quadrant III (T-UE High, T-SCA Low, T-MS High): There were three cadets in quadrant III: C4, C5, and C6. It was suggested that they be assigned to senior units as military staff officers, school units as military instructors, or institutions as tactical instructors. If resources were sufficient, they could be reinvested in the cadets' SCA for on-the-job education.

Quadrant IV (T-UE High, T-SCA Low, T-MS Low): C1 and C7 cadets were in quadrant IV. Since they only had better performance in UE, it was recommended they be assigned to schools as teaching assistants or given educational administration-related positions.

Quadrant V (T-UE Low, T-SCA High, T-MS High): C8 and C9 cadets were in quadrant V. It was suggested that they be assigned to training units as sports instructors or tactical instructors. If resources were sufficient, they could be reinvested in UE for cadets to implement on-the-job education.

Quadrant VI (T-UE Low, T-SCA High, T-MS Low): C13, C14, C15, and C16 cadets were in quadrant VI. Since they only had better performance in SCA, it was recommended they be assigned to grassroots units as sports staff officers and training units as sports instructors.

Quadrant VII (T-UE Low, T-SCA Low, T-MS High): Quadrant VII only contained one cadet, C10. Since only MS performed better, it was recommended for the cadet to be assigned to a grassroots unit as a military staff officer or a training unit as a tactical instructor.

Quadrant VIII (T-UE Low, T-SCA Low, T-MS Low): C11, C12, C17, and C18 cadets were in quadrant VIII. Their overall performance was relatively backward, and it was recommended they be assigned to grassroots units as platoon cadres.

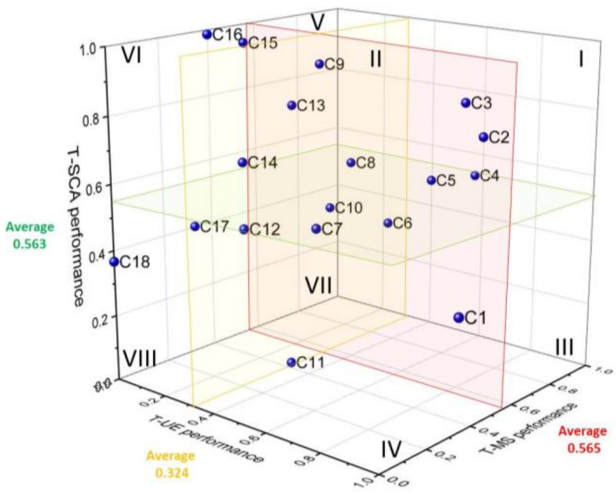

Figure 4. 3D-TOPSIS method for the career competitiveness.

Table 7. The distribution of quadrants for 18 cadets.

Cadets	T-UE performance	T-SCA performance	T-MS performance	Preference value	Quadrant
C1	1.000	0.337	0.334	0.557	IV
C2	0.726	0.707	0.817	0.750	I
C3	0.681	0.809	0.786	0.758	I
C4	0.569	0.528	1.000	0.699	III
C5	0.446	0.504	0.936	0.628	III
C6	0.351	0.367	0.837	0.518	III
C7	0.451	0.469	0.380	0.433	IV
C8	0.246	0.559	0.778	0.528	VII
C9	0.170	0.874	0.715	0.586	V
C10	0.170	0.400	0.764	0.445	VII
C11	0.300	0.000	0.433	0.244	VIII

C12	0.308	0.474	0.228	0.337	VIII
C13	0.097	0.741	0.666	0.501	V
C14	0.175	0.626	0.362	0.388	VI
C15	0.058	0.956	0.493	0.502	VI
C16	0.061	1.000	0.339	0.467	VI
C17	0.028	0.413	0.301	0.247	VIII
C18	0.000	0.367	0.000	0.122	VIII

Discussion

To verify the effectiveness and rationality of the 3D-TOPSIS method, this research compared the ranking of the proposed method with the original rankings of the traditional weighting method and the TOPSIS method. Table 8 shows the summary results. The differences in information processing between the three different research methods were considered when evaluating the criteria, as shown in Table 9.

Table 8. Comparison of rankings by the three methods.

Cadets	Traditional weighting method		TOPSIS method		3D-TOPSIS method		
	GPA	Ranking	C_i	Ranking	Preference value	Ranking	Quadrant
C1	84.71	1	0.624	4	0.557	6	IV
C2	84.40	2	0.749	1	0.750	2	I
C3	84.10	3	0.730	2	0.758	1	I
C4	83.78	4	0.667	3	0.699	3	III
C5	82.87	5	0.592	5	0.628	4	III
C6	81.99	6	0.507	6	0.518	8	III
C7	81.56	7	0.431	9	0.433	13	IV
C8	81.32	8	0.471	7	0.528	7	VII
C9	80.88	9	0.466	8	0.586	5	V
C10	80.74	10	0.419	10	0.445	12	VII
C11	80.52	11	0.313	16	0.244	17	VIII
C12	80.34	12	0.314	15	0.337	15	VIII
C13	80.24	13	0.411	11	0.501	10	V
C14	79.93	14	0.326	14	0.388	14	VI
C15	79.71	15	0.389	12	0.502	9	VI
C16	79.39	16	0.362	13	0.467	11	VI
C17	78.78	17	0.220	17	0.247	16	VIII
C18	77.87	18	0.132	18	0.122	18	VIII

Table 9. Differences in information processing of the three different research methods

Research Method	Consider the longest distance to the negative ideal solution and the shortest distance to the positive ideal solution	Consider the available information from three dimensions	Generates a 3D graphics to provide a reference for personnel assignments and resource allocation
Traditional weighting method	X	X	X
TOPSIS method	O	X	X
3D-TOPSIS method	O	O	O

According to Figure 4, Table 5, and Table 6, it was obvious that the 3D-TOPSIS method had the following advantages.

(1) The 3D-TOPSIS method could consider the longest distance to the negative ideal solution and the shortest distance to the positive ideal solution. The traditional weighting method falls short of accurately representing an individual's career competitiveness, as it can only unilaterally consider an individual's overall GPA. Consequently, it lacks the precision required to make appropriate personnel assignments based on comprehensive criteria, causing the evaluation results to be biased from the actual situation.

(2) The 3D-TOPSIS method could consider the available information from three dimensions. The 3D-TOPSIS method could not only consider the negative ideal solution and the positive ideal solution simultaneously, but also evaluate the career competitiveness of cadets from the perspective of three dimensions, using the T-UE, T-SCA, and T-MS values to simultaneously compute the average relative proximity of each

alternative to the ideal. Therefore, the ranking result was more accurate and reasonable. In contrast, as the traditional weighting method and TOPSIS method can only deal with one-dimensional information, rankings may produce biased results.

(3) The 3D-TOPSIS method could generate a 3D graphics to provide a reference for personnel assignments and resource allocation. The proposed method could adapt different combinations of the cadets' T-UE, T-SCA, and T-MS scores to draw the eight quadrants of the three-dimensional graphics, and the cadets could be allocated to different quadrants to provide personnel assignment and educational resource allocation suggestions.

Conclusion

Assigning military personnel to suitable positions necessitates careful consideration of individual career competitiveness. If senior managers can gain a comprehensive understanding of the actual attributes and distribution of cadets' career competitiveness, it will not only empower the cadets to realize their self-worth but also resolve the challenges in military personnel assignment. This understanding can further facilitate the effective allocation of educational resources, ultimately bolstering the combat power of the troops. The findings of this study offer the following contributions.

(1) Practical contribution: Key performance indicators such as UE, SCA, and MS are crucial in evaluating military personnel for appropriate assignments. However, traditional weighting methods have limitations in adequately addressing individual attributes when assessing cadets' career competitiveness. To overcome this, the research integrates TOPSIS with 3D IPA to propose a novel 3D-TOPSIS method for personnel evaluation. This new approach offers managers a clear 3D visualization, enabling a more immediate and comprehensive understanding of personnel distribution.

(2) Theoretical contribution: The proposed method simultaneously considers both the longest distance from the negative ideal solution and the shortest distance to the positive ideal solution. By incorporating information from three dimensions, it enhances the comprehensiveness of the evaluation. Furthermore, by analyzing the eight quadrants of the three-dimensional diagram, the method provides more effective and accurate results for personnel assignments and the allocation of educational resources.

(3) Social contribution: Taiwan's military personnel often face a loss of human resources due to difficulties in adapting to their assigned units and positions. The career competitiveness evaluation model proposed in this study can effectively address this issue by ensuring that personnel are assigned to positions that best match their attributes.

Although the proposed method accurately assesses the career competitiveness and ranking of military personnel, it does not take into account the subjective weights of the evaluation criteria or the interrelationships among these criteria. In the future, scholars can further explore and extend the application of this method to address diverse military-related MCDM issues, such as cultivation training, resource allocation, and resource management. Additionally, future research can delve into the complexities of personnel assignment under incomplete information, thus advancing the efficiency and effectiveness of personnel management.

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