Research on comprehensive evaluation of quality performance of all employees in electronic equipment enterprises based on entropy method and ideal point method

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Abstract. The overall quality evaluation of electronic equipment is helpful to improve product quality and has become an important focus of quality control. Based on the systematic analysis of job characteristics of all employees, sixteen index frames are constructed from four dimensions of knowledge quality, key quality performance, quality reward and punishment and quality innovation. Secondly, the fuzzy value conversion method is designed with the characteristics of the evaluation index value of electronic equipment, the objective weight is determined by the entropy method, and comprehensive evaluation model is also designed by ideal point method. Finally, a case is given to illustrate the implementation process and feasibility of the proposed method, which can provide theoretical and practical guidance for improving quality performance of all employees.

1. Introduction
As the nerve center of modern weapons and equipment system, electronic information equipment is a variety of equipment that undertakes the functions involving information acquisition, transmission, processing, utilization, attack and defense. It includes command and control, intelligence reconnaissance, early warning detection, communication and navigation, information countermeasures and other operational information assurance functions of the system and related equipment. Electronic information equipment promotes overall operational effectiveness of weapon equipment. The rapid development and extensive application of high-tech weapons and equipment whose core contents are electronic information equipment, are pushing for profound changes in combat theory, military establishment system, combat command, technology and logistics support. Quality evaluation is an important way to understand the quality level and an important starting point to implement the quality control of electronic information equipment products. Due to the fuzziness of quality characteristics, part of quality evaluation takes qualitative evaluation as the main part and quantitative evaluation as the auxiliary part. The comprehensive evaluation of electronic equipment in mixed fuzzy environment has become an important scientific problem.

Many scholars have studied the problem of quality evaluation. Weibull parameter proportional hazard model was used to estimate cable failure efficiency [1]. Li proposed an improved piecewise reliability model for information criterion testing and evaluation [2]. Sharp adopted probability design and failure analysis to evaluate reliability [3]. Efrosinin used Laplace transform to calculate reliability characteristics and functions [4], and Jian combined with the basic idea of life cycle theory, proposed the product maintainability evaluation method [5]. Singh applied graph theory method to evaluate the
maintainability and other quality levels of equipment system [6]. Yin aimed at the fuzziness of expert judgment factors, a testability allocation method based on triangular fuzzy numbers was proposed based on multi-source prior information and Bayesian theory [7]. A testable quantitative evaluation model was constructed by Tang [8]. Wang quantitatively evaluated the testability of software based on entropy method and fault tree analysis method [9]. Cheng designed the equipment support evaluation model and algorithm based on SPA-AHM [10], and Yang proposed a comprehensive evaluation method of aviation maintenance support capability based on principal component analysis [11]. Shi [12] proposed an equipment maintenance support capability evaluation method based on binary semantics. Wu presented a security evaluation method based on grey clustering and FAHP method [13]. D A designed a system safety evaluation method based on system theoretical process analysis [14]. An optimal safety evaluation model for complex product systems was proposed by comprehensively considering index correlation and redundancy based on cluster analysis and neural network by Li. Chen proposed an equipment safety evaluation model [16].

Generally speaking, the above literatures mainly used quantitative methods to evaluate the six properties of complex equipment such as electronics, and had achieved fruitful research results. It is necessary to involve qualitative and quantitative indexes in terms of overall quality evaluation of electronic equipment enterprises. In order to build a scientific comprehensive quality evaluation model for all employees, this paper constructs the corresponding evaluation index system based on the analysis of the quality requirements for all employees in electronic equipment enterprises, and applies ideal point method to implement comprehensive evaluation, which can provide theoretical and practical guidance for improving the quality level of all employees in electronic equipment enterprises.

2. Introduction
The whole staff of electronic equipment is mainly designers, managers and production operators. The quality of all kinds of personnel is mainly reflected in basic quality knowledge accomplishment, basic quality performance, quality improvement, rewards and punishments, etc. Combined with the relevant requirements of job descriptions of the three types of personnel, work performance of all personnel and their development status, this paper believes that corresponding quality index system can be designed according to three dimensions of basic knowledge quality, basic quality performance of personnel and innovative development performance of personnel.

2.1. Basic knowledge quality
All kinds of personnel in electronic equipment enterprises need have basic quality knowledge that matches their work requirements. For example, management personnel need to pay attention to the requirements of educational background, work experience, professional knowledge, working ability, psychological quality and document writing. Design personnel need a certain degree, different design positions need job years, professional qualifications and title requirements, professional knowledge requirements, design ability requirements. Production operators not only need have the requirements of working years, technical level, professional basic knowledge requirements, general or special ability to complete the relevant tasks, and so on.

Basic information such as working years, professional qualifications and professional titles, which can be quantified and easily obtained by consulting educational certificates or reviewing relevant certificates. The knowledge level of professional ethics, leadership, communication, innovation and other abilities of specific positions should be measured by means of written test, leaderless group discussion and daily assessment. The actual operation assessment can be conducted by observing the actual situation of quality management work, evaluating the mastery and application of quality management methods and skills, and comprehensively investigating the ability of quality planning, quality analysis, quality control, quality improvement and other aspects.

2.2. Key quality performance
The key quality performance of electronic equipment enterprises is closely related to its work content. For example, project management personnel pay attention to project delivery on-time rate, project planning completion rate, project review closed-loop rate, major technical research project completion rate, project first piece appraisal completion rate, completeness and accuracy of various reports and reports, and project summary completion rate. Quality management personnel pay attention to the completion rate of quality target plan, quality system audit and approval rate, quality technology promotion plan completion rate, quality information data statistical analysis accuracy.

Production operators belong to front-line staff, and their task completion rate (including after-sales technical service and repair parts), qualification rate of first delivery, satisfaction of next post, safety accidents, leakage incidents and other core performance indicators.

The quality is designed rather than produced, and work quality level of designers directly affects final quality of electronic equipment. For example, the basic performance of overall plan designer of electronic equipment is the overall plan, design specification, technical level of various reports and document quality. The correctness, completeness and timeliness of the sub-system development task; The completion of the plan in the stage of equipment development; The completion of the plan of internal and external field joint test of equipment development; Error rate of scheme design and ability to solve technical problems; Team spirit and coordination ability in product development; Work attitude; Ability to update knowledge and adopt new technology, etc.

2.3. Quality innovation and rewards and punishments

Innovation and development were the eternal theme facing any enterprise. The quality rewards and punishments for electronic equipment personnel mainly use economic levers to reward the contributors engaged in quality work and punish those with low quality performance. The purpose is to strengthen internal management, enhance the quality awareness and excellence awareness of all staff, improve the credibility and popularity of the enterprise, and enhance the market competitiveness of the enterprise. Quality innovation is an important aspect of performance evaluation of quality personnel, as well as an important cornerstone of quality management and level improvement. It is particularly important to motivate employees to make innovation. Common indicators include training expenditure, training cycle, employee satisfaction, employee turnover rate, information coverage ratio, the number of Suggestions proposed by each employee, the proportion of Suggestions adopted, the effectiveness of Suggestions adopted, and the satisfaction of team members.

Based on the quality performance dimension analysis of the above three types of personnel, combined with the existing quality evaluation contents and dimensions of various types of personnel in electronic equipment enterprises, and considering data source availability and quantifiable characteristics of personnel quality index, the following evaluation index system is given. This index system is aimed at three kinds of people, and the evaluation index is calculated by annual summary.

Table 1. Table of quality evaluation index system for all employees.

| Quality index | Code | Detailed index | Index explanation |
|---------------|------|----------------|-------------------|
| Knowledge quality | $c_1$ | The matching degree of working ability. | The matching degree of work experience and knowledge with job requirements |
|                 | $c_2$ | Degree of professional knowledge of the post. | The professional knowledge of the position is in line with its specialty |
|                 | $c_3$ | Staff attitude | Attendance or supervisor leadership evaluation |
Key performance

$c_4$ Annual quality plan completion rate  
The percentage of the total number of quality work plans actually completed on time.

$c_5$ Document and information communication accuracy.  
The ratio of nonconforming materials to all materials.

$c_6$ Documentation pass rate.  
The ratio of one pass document to the total document.

$c_7$ Users' satisfaction  
Sampling the mean satisfaction of the next process object.

$c_8$ Job qualification rate  
The proportion of qualified tasks in total tasks.

$c_9$ Internal and external honors.  
Accumulated scores of various internal and external honors.

The quality of rewards and punishments

$c_{10}$ Contribution to solving quality problems.  
Reward for solving various quality accidents or problems.

$c_{11}$ Financial saving value.  
Reduce cumulative points for all types of losses.

$c_{12}$ Event Count  
The weighted number of violations, baseline, and red line events.

Quality Innovation

$c_{13}$ Number of quality improvements.  
The number of weights that lead or participate in quality improvement.

$c_{14}$ Annual training volume.  
Total hours of annual quality training.

$c_{15}$ Number of lectures per year.  
Annual total class hours of external teaching.

$c_{16}$ Number of cases and papers.  
Number of cases or papers published per year.

In the above evaluation index system table, $c_1, c_2, c_3$ and $c_7$ are fuzzy values, represented by language values, representing four grades of excellent, good, medium and poor. Other index values are quantitative values, which can be calculated by collecting corresponding data. For the quality reward and punishment and quality innovation indicators, the honors of national, provincial and municipal are 3, 2 and 1 score respectively. In terms of the contribution to solving quality problems, 4, 3, 2 and 1 score will be awarded respectively according to solving super, major, medium and general problems. The financial savings value is calculated at 1 score per 10,000 yuan, based on the amount of loss expected to be saved. In terms of the number of events, 6, 3 and 1 score are given for each of the three types of events. The number of quality improvements mainly divides quality improvements into major, medium and general improvements, giving weight to 6, 3 and 1 score respectively. According to the number of annual published cases or papers, the case should be any high-level case of the unit, with 3 score for each paper, which is divided into SCI, CSSCI, Core journals of Peking University, provincial core journals, etc., with 10, 5, 3 and 1 score respectively.

3. Design of hybrid quality evaluation model for electronic equipment enterprises.

Assume that the total number of evaluation objects of electronic equipment enterprises is $A = (a_1, \ldots, a_m)$. The evaluation indexes are the above 16 evaluation indexes. It’s the set of index weight values to indicated as $c = (c_1, \ldots, c_n)$, $\omega = \{w_j, j = 1, 2, \ldots, n\}$. Evaluation value is $X = [x_j]$. 

Because some values are fuzzy values and some are clear values, this problem is a mixed fuzzy comprehensive evaluation problem.

For this kind of mixed multi-attribute decision making problem, this paper adopts the following method to deal with fuzzy values and convert them into clear Numbers.

For the specific data of the four grades of excellent, good, medium and poor, it can be converted into triangular fuzzy numbers according to the corresponding table, namely (1,0.8,0.6), (0.8, 0.6,0.4), (0.6,0.4,0.2), (0.4,0.2,0). Transform it into a clear number by \[ \frac{l_1 + ml_2 + l_3}{m+2} \]. Therefore, this paper describes the above multi-attribute evaluation steps of electronic equipment as follows:

**Step 1:** Dimensionless processing of original data according to range transform method.

For the benefit attribute \( y_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \).

For cost attributes \( y_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \).

Finally, a standardized evaluation matrix for all electronic equipment staff is formed \( Y = \begin{bmatrix} y_{ij} \end{bmatrix} \).

**Step 2:** Calculate the objective weight according to the entropy method. First, the normalized evaluation matrix is processed. \( z_{ij} = \frac{y_{ij}}{m} \). Second, calculate the entropy \( e_j = -\frac{\sum_{i=1}^{m} z_{ij} \ln z_{ij}}{\ln m} \). And end up with weights \( w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \).

**Step 3:** Select ideal and negative ideal points of the normalized matrix. Firstly, the assessment matrix of weights is constructed \( WY = \begin{bmatrix} w_j y_{ij} \end{bmatrix} \). Secondly, find the maximum and minimum values for each row and column.

\[
\begin{align*}
P &= (\max w_1 y_{i1}, \ldots, \max w_n y_{in}) \\
N &= (\min w_1 y_{i1}, \ldots, \min w_n y_{in})
\end{align*}
\]

**Step 4:** Calculate the distance of each scheme, that is, the distance between employees and positive and negative ideal points.

\[
\begin{align*}
 &d^{+}_i = \sqrt{\sum_{j=1}^{n} (w_j y_{ij} - \max w_j y_{ij})^2} \\
 &d^{-}_i = \sqrt{\sum_{j=1}^{n} (w_j y_{ij} - \min w_j y_{ij})^2}
\end{align*}
\]

**Step 5:** Calculate the relative closeness of each person.

\[
cc_j = \frac{d^{-}_i}{d^{+}_i + d^{-}_i}
\]

According to the relative closeness degree, the final evaluation result is obtained in order from large value to small value.

4. **Case study**
In an electronic equipment enterprise, six personnel participated in the comprehensive evaluation of quality performance. The dimensions of evaluation are respectively the above sixteen indicators, and the evaluation values are shown in the table below.

**Table 2. The table of evaluation matrix.**

| Code | Detailed index                                      | Staff 1  | Staff 2  | Staff 3  | Staff 4  | Staff 5  | Staff 6  |
|------|-----------------------------------------------------|----------|----------|----------|----------|----------|----------|
| $c_1$| The matching degree of working ability.             | Excellent| Good     | Medium   | Good     | Excellent| Poor     |
| $c_2$| Degree of professional knowledge of the post.       | Good     | Medium   | Excellent| Good     | Medium   | Good     |
| $c_3$| Staff attitude                                     | Medium   | Good     | Excellent| Medium   | Medium   | Excellent|
| $c_4$| Annual quality plan completion rate                | 0.96     | 0.98     | 0.92     | 0.95     | 0.88     | 0.97     |
| $c_5$| Document information communication accuracy.       | 0.87     | 0.95     | 0.94     | 0.89     | 0.98     | 0.91     |
| $c_6$| Documentation pass rate                            | 0.94     | 0.88     | 0.91     | 0.94     | 0.92     | 0.95     |
| $c_7$| Users' satisfaction                                | 0.78     | 0.85     | 0.82     | 0.90     | 0.85     | 0.88     |
| $c_8$| Job qualification rate                             | 0.92     | 0.94     | 0.96     | 0.89     | 0.86     | 0.91     |
| $c_9$| Internal and external honors.                      | 32       | 21       | 45       | 23       | 36       | 17       |
| $c_{10}$| Contribution to solving quality problems.         | 21       | 27       | 13       | 32       | 24       | 30       |
| $c_{11}$| Financial saving value.                          | 10.4     | 8.9      | 12.8     | 3.6      | 20.7     | 30.7     |
| $c_{12}$| Event Count                                      | 7        | 6        | 1        | 5        | 4        | 8        |
| $c_{13}$| Number of quality improvements.                    | 12       | 21       | 6        | 14       | 23       | 19       |
| $c_{14}$| Annual training volume.                           | 3        | 1        | 2        | 5        | 4        | 7        |
| $c_{15}$| Number of lectures per year.                      | 10       | 8        | 12       | 21       | 7        | 11       |
| $c_{16}$| Number of cases and papers.                       | 16       | 14       | 24       | 32       | 43       | 29       |

**Step 1:** The result is obtained by means of range transformation.

**Table 3. The normalized evaluation matrix.**

| Code | Staff 1  | Staff 2  | Staff 3  | Staff 4  | Staff 5  | Staff 6  |
|------|----------|----------|----------|----------|----------|----------|
| $c_1$| 1.000    | 0.667    | 0.333    | 0.667    | 1.000    | 0.000    |
| $c_2$| 0.500    | 0.000    | 1.000    | 0.500    | 0.000    | 0.500    |
| $c_3$| 0.000    | 0.500    | 1.000    | 0.000    | 0.000    | 1.000    |
Step 2: Calculate the objective weights according to the entropy method, and get the weights as: 0.067, 0.057, 0.046, 0.068, 0.064, 0.068, 0.067, 0.066, 0.061, 0.062, 0.062, 0.067, 0.063, 0.056, 0.061.

Step 3: Calculate the weighted evaluation matrix and get the ideal and negative ideal points.

Table 4. The weighted evaluation matrix and positive and negative ideal points.
Step 4: Calculate the distance between each alternative and the ideal point.

Table 5. The distance and relative closeness of each alternative.

| Code | Staff 1 | Staff 2 | Staff 3 | Staff 4 | Staff 5 | Staff 6 |
|------|---------|---------|---------|---------|---------|---------|
| \(d^+_i\) | 0.0284  | 0.0280  | 0.0239  | 0.0183  | 0.0225  | 0.0185  |
| \(d^-_i\) | 0.0165  | 0.0200  | 0.0229  | 0.0261  | 0.0266  | 0.0312  |
| \(cc_i\)  | 0.3673  | 0.4170  | 0.4888  | 0.5879  | 0.5418  | 0.6279  |

Therefore, the comprehensive performance of personnel can be ranked as staff 6, staff 4, staff 5, staff 3, staff 2 and staff 1.

5. Conclusion

This paper mainly evaluates comprehensive quality performance of all employees in electronic equipment enterprises. Based on job characteristics, key performance, innovation and other characteristics of the staff, the corresponding evaluation index system was constructed, where the indexes developed are the first index systems for quality credit. The objective weight was determined according to entropy method, and ideal point method was used to implement the process of comprehensive evaluation. We provide some theoretical and practical guidance for comprehensive quality evaluation of all employees, and has certain theoretical significance for improving the comprehensive quality of relevant employees. In the paper, we apply comprehensive evaluation method incorporating objective weight and TOPSIS, other than the linear weighting method, which will show the feasibility and availability of the decision results in practices and illustrate the superiority of integrating methods in multi-index employee management.

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