Multiobjective Optimization Model of Quality Education Reform in Research and Learning Activities

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In order to solve the problem of quality education reform in research activities, a multiobjective optimization model for the optimal performance distribution of college teachers is proposed. We mainly use the multiobjective optimization method to study the allocation of optimal performance. On the basis of considering individual differences, a multiobjective optimization model is established with the goal of maximizing the total satisfaction of all assessment objects and balancing the satisfaction as much as possible by introducing the score conversion function and the satisfaction function. The results show that the variation trends of the weak Pareto fronts at five different confidence levels are basically the same; that is, different confidence levels have little effect on the results. Conclusion. The use of a multiobjective optimization model can improve the optimal performance distribution of college teachers, so as to effectively promote the reform of quality education in research activities.

1. Introduction

Quality education mainly refers to a new educational model that aims to improve students’ quality in all aspects and promote students’ personal development to adapt to social development [1]. With the continuous reform of quality education, colleges and universities, as the main position to cultivate high-quality talents, should firmly grasp the pulse of the development of the times. It is particularly urgent to reform and practice characteristic quality education. As a unique group with vigor and vitality, college students’ curiosity, independence, and thirst for knowledge all have distinctive personal characteristics and characteristics of the times. We should carry out characteristic quality education in Colleges and universities, strengthen education guidance, send more compound talents to the society, promote the all-round development of the social economy, and make positive contributions to the prosperity of the country and the revitalization of the nation. Therefore, we should carry out the reform and practice of characteristic quality education, gradually establish and improve a scientific and reasonable characteristic quality education system for college students, and continuously cultivate diversified and all-round talents with a sense of responsibility on the premise of fully respecting the wishes and actual conditions of college students, so as to respond to the needs of national development for talents.

As we all know, the research on performance distribution has very important theoretical significance and application value for the efficient operation of government, enterprises, schools, hospitals, and other institutions [2]. However, at present, few people use the multiobjective optimization model to study the performance distribution. At the same time, we also note that the optimal performance distribution scheme not only depends on the effective aggregation of index scores at all levels but also is related to many factors such as the individual differences of the appraisees and the requirements of basic workload [3]. Inspired by the research work, this paper mainly studies the application of a multiobjective optimization model in the optimal performance allocation problem. Based on the individual differences of the appraisees in the performance distribution, all appraisees are
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classified. Taking the control parameters reflecting the incentive degree and the basic workload of all appraisees as variables, the score conversion function and the satisfaction function describing the satisfaction of the appraisees are introduced to establish a multiobjective optimization model with the goal of maximizing the overall satisfaction of all appraisees and balancing the satisfaction as much as possible [4]. Furthermore, the existence of weak efficient solutions of the multiobjective optimization model is proved by using the constraint scalarization method. In its application, this paper takes the scientific research work and mathematical work completed by the examinee as the evaluation index, uses the multiobjective optimization model to study the optimal performance allocation of teachers in a university, and uses a genetic algorithm to carry out numerical experiments [5] as shown in Figure 1.

2. Literature Review

At present, there are two main changes in the construction of general education courses in Chinese colleges and Universities: first, general education elective courses have grown from scratch, from less to more, and have developed from focusing on increasing “quantity” to improving “quality”, starting to build the core courses of general education. After more than 20 years of development, colleges and universities have opened as many as 200 or 300 general education elective courses, most of which cover the three knowledge fields of humanities, social sciences, and natural sciences. Most colleges and universities adopt the method of distributed electives; that is, the general elective courses are divided into several modules according to the nature of the discipline, requiring students to take certain credits from different fields. The general education elective course is an independent course set up by Chinese colleges and universities to highlight the idea and characteristics of quality education. At the initial stage of its establishment, due to the lack of deep understanding and effective management, general education elective courses generally had the problems of "miscellaneous content, disordered structure, poor quality, and low status," which made it difficult to effectively play the role of quality education. In recent years, some universities have strengthened the top-level design and policy support of general elective courses and started to focus on building a number of "general core courses" on the basis of the original general elective courses. Some colleges and universities have also set up general education curriculum committees to hire scholars from multiple disciplines to conduct overall design and quality audits of general education curriculum. This series of measures have made general education elective courses develop towards "systematization, standardization, high-quality products, and core," and the quality and status of the curriculum are improving. This puts forward higher requirements for the optimal performance of university teachers.

Even so, in universities with a large number of professional colleges and departments, quality education or general education institutions without discipline and specialty inevitably have to be in an awkward position of "powerless and powerless". Therefore, in order to fundamentally improve the status of general education, we also need deeper organizational system reform. In fact, the Department of a University is not only a first-class administrative institution but also an institution that connects a certain type of discipline and specialty. That is to say, the organizational form of the Department holds the personnel of different disciplines together, further clarifies the boundaries between different disciplines, and forms discipline barriers in the form of administrative institutions. Accordingly, the curriculum and teaching system are also organized with the discipline as the center, thus realizing the goal of professional talent training. On the surface, the implementation of quality education needs to reform the curriculum. In fact, it is a comprehensive reform of the University. It is a reconsideration of the educational purpose of the University, a repositioning of the teaching objective of undergraduate education, and a reconstruction of the talent training mode and will eventually involve the reform of the management system and even the organizational system of the University.

Aiming at this research problem, Yao, W. W. believes that colleges and universities, as the main position for talent training, mean to promote the all-round development of students in all aspects through the training of college students [6]. We should fully realize the importance of the reform of characteristic quality education and put the characteristic quality education through the whole process of higher education, so that the cultivation of quality talents in Colleges and universities is no longer superficial. Nyamutata believes that on the one hand, it can improve students’ ideological construction, cultivate students’ awareness of self-study, competition and innovation, and enable students to learn and grow under the correct guidance of education; on the other hand, the characteristic quality education activities can also cultivate students’ innovation ability and practical ability, stimulate students’ learning potential to the greatest extent, link the cultivation of talents with the needs of the market, enterprises, and society, and promote students’ social employment and life development [7]. Diab believes that performance evaluation is widely used in many aspects, such as the comprehensive performance assessment of enterprise employees, the work quality assessment of university teachers or administrative personnel, the comprehensive performance assessment of bank employees, and the ecological environment assessment [8].

On the basis of the current research, this paper proposes a multiobjective optimization model for the optimal performance allocation of university teachers, specifically taking the scientific research and mathematical work completed by the assessment object as the assessment index, using the multiobjective optimization model to study the optimal performance allocation of a university teacher, and using the genetic algorithm to carry out numerical experiments [9].

3. Research Methods

3.1. Construction of Score Conversion Function Model. As the performance distribution needs to reflect a certain degree of incentives to the appraisees and the quantitative standards of different types of indicator scores may be different, it is necessary to introduce the score conversion function to
Cognitive ability

Media types

Learning needs

Learning time

Learning content

3.2. Range Estimation of Displacement. If \( \lambda_1 = 0 \) or \( \lambda_2 = 0 \), the conversion score of the first or second appraisal indicator of all appraisees is 0, which is inconsistent with the actual situation. Therefore, this paper assumes that \( \lambda_j \geq \lambda_j^l \), where \( \lambda_j \) is a sufficiently small positive number. Similarly, if \( \lambda_1 \rightarrow +\infty \) or \( \lambda_2 \rightarrow +\infty \), this is also inconsistent with the actual situation. Therefore, this paper assumes that \( \lambda_j \leq \lambda_j \), where \( \lambda_j = 0 \), \( j = 1, 2 \). Obviously, the basic workload \( x_j \geq 0 \), \( j = 1, 2 \). However, the basic workload should be as large as possible. For example, when \( x_j = \max \{ a_{ij}, a_{ij}, \ldots, a_{ij} \} \), \( j = 1, 2 \), the conversion score of the \( j \) indicator of all appraisees is 0. This is obviously not in line with the actual situation. Therefore, it is necessary to estimate the upper bound of the basic workload [12]. It is assumed that the scores of each category of indicators of different types of appraisees are not all the same and follow the normal distribution [13]. Since the basic workload corresponding to various assessment indicators should not deviate too much from the average level of all assessment objects, this paper takes the upper bound of the expected value of normal distribution as the upper bound of the basic workload of assessment indicators. Let \( \bar{X}_{11} \) and \( \bar{X}_{22} \), respectively, represent the sample mean value of the \( j \)-th assessment indicator score of type I and type II appraisees, and then, formula (3) is as follows:

\[
\bar{X}_{11} = \frac{a_{11} + a_{21} + \cdots + a_{11}}{s},
\]

\[
\bar{X}_{12} = \frac{a_{12} + a_{22} + \cdots + a_{22}}{s},
\]

\[
\bar{X}_{21} = \frac{a_{s+1,1} + a_{s+2,1} + \cdots + a_{p1}}{p - s},
\]

\[
\bar{X}_{22} = \frac{a_{s+1,2} + a_{s+2,2} + \cdots + a_{p2}}{p - s}.
\]

Let \( s_{1j} \) represent the sample standard deviation of the score value of the \( j \)-th appraisal indicator of the type I appraisee, and \( s_{2j} \) represent the sample standard deviation of the score value of the \( j \)-th appraisal indicator of the type II appraisee, and then, the corresponding sample variances are shown in the following formula:

\[
S_{11} = \frac{1}{s - 1} \sum_{i=1}^{s} \left( a_{11} - \bar{X}_{11} \right)^2,
\]

\[
S_{12} = \frac{1}{s - 1} \sum_{i=1}^{s} \left( a_{12} - \bar{X}_{12} \right)^2,
\]

\[
S_{21} = \frac{1}{p - s - 1} \sum_{i=s+1}^{p} \left( a_{11} - \bar{X}_{21} \right)^2,
\]

\[
S_{22} = \frac{1}{p - s - 1} \sum_{i=s+1}^{p} \left( a_{12} - \bar{X}_{22} \right)^2.
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\bar{X}_{21} = \frac{a_{s+1,1} + a_{s+2,1} + \cdots + a_{p1}}{p - s},
\]

\[
\bar{X}_{22} = \frac{a_{s+1,2} + a_{s+2,2} + \cdots + a_{p2}}{p - s}.
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Let \( s_{1j} \) represent the sample standard deviation of the score value of the \( j \)-th appraisal indicator of the type I appraisee, and \( s_{2j} \) represent the sample standard deviation of the score value of the \( j \)-th appraisal indicator of the type II appraisee, and then, the corresponding sample variances are shown in the following formula:

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\]

\[
S_{12} = \frac{1}{s - 1} \sum_{i=1}^{s} \left( a_{12} - \bar{X}_{12} \right)^2,
\]

\[
S_{21} = \frac{1}{p - s - 1} \sum_{i=s+1}^{p} \left( a_{11} - \bar{X}_{21} \right)^2,
\]

\[
S_{22} = \frac{1}{p - s - 1} \sum_{i=s+1}^{p} \left( a_{12} - \bar{X}_{22} \right)^2.
\]
Therefore, when the confidence level is $1 - \alpha$, the two unilateral upper confidence limits of the basic workload $x_i$ of the first type of assessment indicator are $\overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})$, $\overline{X}_2 + t_a (p - s - 1) (S_2/\sqrt{p - s})$, respectively. In order to allow as many assessment objects as possible to participate in the performance distribution, this paper takes $\min \{ \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s}), \overline{X}_2 + t_a (p - s - 1) (S_2/\sqrt{p - s}) \}$ as the upper bound of the basic workload $x_i$. Similarly, it can be obtained that the upper bound of the basic workload $x_2$ of type 2 assessment indicator is shown in the following equation:

$$\min \left\{ \overline{X}_{12} + t_a (s - 1) \frac{S_{12}}{\sqrt{s}}, \overline{X}_{22} + t_a (p - s - 1) \frac{S_{22}}{\sqrt{p - s}} \right\}.$$  

(5)

3.3. Satisfaction Function. This section mainly proposes the satisfaction function to describe the satisfaction of the appraisee with the distribution scheme and then proves the continuity of the satisfaction function in the estimation interval of the variable [14]. Note $Y_i = \sum_{i=1}^{p} y_{ij} / \sqrt{\sum_{i=1}^{p} (y_{ij})^2}$, the satisfaction function proposed in this paper satisfies the condition that $\forall x \in [0, \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})]$, the satisfaction function should increase with the increase of the distribution proportion $Y_i$, and the greater the distribution proportion, the more difficult it will be to improve the satisfaction of the appraisees, this paper proposes the following satisfaction function (7):

$$f_i(Y_i) = \left( \frac{Y_i - L_i}{U_i - L_i} \right)^{1/2}. $$  

(7)

Obviously, when $Y_i = U_i$, the satisfaction of the i-th appraisee is 1; that is, the allocation proportion is the most favorable for the i-th appraisee; when $Y_i = L_i$, the satisfaction of the i-th appraisee is 0; that is, the allocation proportion is the most unfavorable to the i-th appraisee [15]. According to the satisfaction function constructed in this paper, if the performance allocation proportion of the i-th appraisee is closer to $U_i$, that is, the higher the allocation proportion is, the higher the value of the satisfaction function is. On the contrary, the value of the satisfaction function will be lower. On the other hand, as the proportion of appraisees increases, appraisees will have higher expectations of themselves. Therefore, it will become more difficult to further improve the satisfaction of appraisees. The satisfaction function proposed in this paper satisfies $f'' < 0$, which just expresses this meaning.

Therefore, the satisfaction function proposed in this paper reflects the satisfaction of the appraisees with the performance distribution scheme to a certain extent. The continuity of the satisfaction function on the estimation interval of the variable is proved as shown in the following equation:

$$m_j = m \{ a_{1j}, a_{2j}, \ldots, a_{pj} \},$$

$$m_j' = m \{ a_{1j}, a_{2j}, \ldots, a_{pj} \},$$

$$M_j = m \{ a_{1j}, a_{2j}, \ldots, a_{pj} \},$$

$$M_j' = m \{ a_{1j}, a_{2j}, \ldots, a_{pj} \}.$$  

(8)

Theorem 1. If $a > 0.05, s \geq 6, p - s \geq 6$, and the index scores of various appraisees meet the following formula:

$$\left| \frac{m_j - X_{1j}}{M_j - X_{1j}} \right| \leq 1, \left| \frac{m_j' - X_{2j}}{M_j' - X_{2j}} \right| \leq 1, j = 1, 2. $$  

(9)

Then, the following conclusion is true:

(i) At least one appraisee’s type 1 appraisal indicator score is greater than the upper bound of the basic workload $x_1$.

(ii) There is at least one appraisee whose score of category 2 appraisal index is greater than the upper limit of basic workload $x_2$.

Only Case (I) and similar Case (II) can be proved. If $\overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s}) \leq \overline{X}_2 + t_a (p - s - 1) (S_2/\sqrt{p - s})$, the estimation interval of variable $x_1$ is $[0, \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})]$. Issue certificate $M_j > \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})$, then $f_i(Y_i) = (M_j - \overline{X}_1 - x_1)^2 < (M_j - \overline{X}_1 - x_1)^2$. If $M_j \leq \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})$, it can be known from the condition that $(a_{1j} - \overline{X}_1)^2 \leq \min \{ (m_1 - \overline{X}_1)^2, (M_1 - \overline{X}_1)^2 \} = (M_1 - \overline{X}_1)^2 (1 \leq i \leq s)$ and then $t_a (s - 1) (S_1/\sqrt{s}) \leq t_a (s - 1) (S_1/\sqrt{s})$, the estimation interval of variable $x_1$ is $[0, \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})]$. If $M_j > \overline{X}_1 + t_a (s - 1) (S_1/\sqrt{s})$, then $f_i(Y_i) = (M_j - \overline{X}_1 - x_1)^2 < (M_j - \overline{X}_1 - x_1)^2$. Therefore, $f'' < 0$ can be known from the conditions.

4. Results and Discussion

This section mainly uses the multiobjective optimization model established above to study the optimal performance allocation of high school teachers. Taking a secondary unit of a university as an example, 86 teachers were assessed from two aspects of teaching and scientific research. Table 1 shows the scores of teaching assessment indicators and scientific research assessment indicators of 86 teachers [16, 17].
According to the data in Table 1, the assessment objects are divided into two types: teaching type and scientific research type, in which the teaching type teacher \( s = 48 \). Obviously, the data in Table 1 meet the conditions of Theorem 1. It is calculated that when the confidence level is 0.95, the estimation intervals of basic workload \( B \) of teaching assessment indicators and basic workload \( C \) of scientific research assessment indicators are \( [0, 356.91] \), \( [0, 790.72] \). Take \( \alpha_1 = \alpha_2 = 0.1 \), \( l_1 = l_2 = 10 \). To simplify the calculation, let \( d = 1 \), then equation (10) is as follows:

\[
g_k(\xi, x_1, x_2) = f_k(\sqrt{L_k}) = \sqrt{\frac{1}{U_k - L_k} \sum_{i=1}^{p} \mu_i \lambda_i (a_{k1} - x_1)^2 + \sum_{i=1}^{p} \mu_i \lambda_i (a_{k2} - x_2)^2} \frac{L_k}{U_k - L_k}
\]

\[
= \sqrt{\frac{1}{U_k - L_k} \sum_{i=1}^{p} \mu_i \lambda_i (a_{k1} - x_1)^2 + \sum_{i=1}^{p} \mu_i \lambda_i (a_{k2} - x_2)^2} \frac{L_k}{U_k - L_k}
\]

Where \( \xi \in [0.01, 100] \), then (MOP) can turn into (MOP), \( \min_{\xi, x_2} \sum_{i \in [j, j+j-1]} (g_i(\xi, x_1, x_2) - g_j(\xi, x_1, x_2) + \sum_{k=1}^{2} \sum_{i=1}^{p} \mu_i \lambda_i (a_{k1} - x_1)^2 + \sum_{i=1}^{p} \mu_i \lambda_i (a_{k2} - x_2)^2} \frac{L_k}{U_k - L_k}
\)

It can be seen from Figures 3 and 4 that although different Pareto solutions correspond to the performance distribution proportion of the appraisees and the satisfaction of the appraisees, there is only a small gap [20]. Therefore, when making decisions, the decision-maker only needs to select a group of weak Pareto solutions arbitrarily to obtain a performance allocation scheme based on the highest possible total satisfaction of the appraisees and the most balanced satisfaction of the appraisees [21, 22]. The weak Pareto fronts at different confidence levels are given below, as shown in Figure 5.

It can be seen from Figure 5 that the change trend of weak Pareto front under five different confidence levels is basically the same; that is, different confidence levels have little impact on the results [23–25]. Aiming at the
aggregation problem of evaluation scores in performance evaluation, this paper establishes a new multiobjective optimization model and uses genetic algorithm to solve the model. The numerical results show that the method used in this paper has obvious advantages.

This paper mainly uses the multiobjective optimization method to study the distribution of optimal performance. On the basis of considering individual differences, by introducing the score conversion function and the satisfaction function, the maximization and satisfaction of the total satisfaction of all assessment objects are established. A multiobjective optimization model with the goal of balancing as much as possible proves the existence of weak effective solutions of the model and studies its application in teacher performance distribution in high schools.

### 5. Conclusion

This paper presents a multiobjective optimization model for the optimal performance allocation of university teachers. Taking the scientific research and mathematical work completed by the examinees as the assessment indicators, this paper studies the optimal performance allocation of university teachers by using the multiobjective optimization model, and carries out numerical experiments by using genetic algorithm. This paper mainly uses multiobjective optimization method to study the allocation of optimal performance. On the basis of considering individual differences, by...
differences, by introducing score transformation function and satisfaction function, a multiobjective optimization model is established with the goal of maximizing the total satisfaction of all assessment objects and balancing the satisfaction as much as possible. Then, the existence of a weak efficient solution of the model is proved, and its application in the performance distribution of university teachers is studied.

**Data Availability**

The data used to support the findings of this study are available from the corresponding author upon request.

**Conflicts of Interest**

The authors declare no conflicts of interest.

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