A Study on the Construction of Talent Growth Coordinate System Based on Competency Model of Technological College Students

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Keywords: Technological college students; Competency Model; Talent Growth Coordinate System

Abstract. Nowadays, it has become the new focus for technological colleges to creatively enhance the effect of talent cultivation by putting both the Competency Model for their students and the social needs into consideration. Based on the theoretical foundation of Competence Model and a thorough analysis of such model for technological college students, the article is able to put forward and afterwards build the Talent Growth Coordinate System, namely an index system for students’ competency with three mutually integrated facets. Those three facets are requirements of the society, university objects of talent cultivation as well as the personal development of student. The above Talent Growth Coordinate System aims to achieve the following four goals. Firstly, the system will make it more convenient for universities to have a better understanding of student development. Besides, the system will improve the individualization of educational means. Furthermore, the assessment result of such system can reflect the degree of students’ adaption for industries and enterprises. Fourthly, it will lead to the development of career planning and employment recommendation work in universities.

1. The present situation and challenge of technological college students cultivation and career development

1.1 Present situation of technological college students’ cultivation

Driven by the two factors of scientific and technological advance and global integration, engineering science and technology, which is closely related to the pace of industrialization, play an increasingly important role in today's economic and social development \cite{1}. Engineering is the application of mathematics, physics, chemistry and other basic disciplines of the principles, combined with the accumulation of production practice of the technology. In another word, applying the principles of science and technology to solve problems \cite{2}. Now the scale of China's technological education is the first in the world, as well as higher education \cite{3}. Thus, technological education plays an important role in higher education.

With the evaluation standards in technological related enterprises become more and more explicit, there are increasingly high requirements to improve the comprehensive quality and employment ability of college students to meet the practical needs of social imperative. How to evaluate the overall quality of college students more scientifically, objectively and accurately, has become the focus of attention of all sectors of society. Under the new era, the training of technological students and their career development has ushered in new opportunities and new challenges.

1.2 The dilemma of career development of college students and enterprise recruitment

At present, there are many problems in technological colleges, such as students confusing with their career planning. Therefore, it’s hard for college to cultivate students. Employers’ requirements become higher and their satisfaction for graduates needs to be improved. With employment pressure and other practical difficulties, the problem about personnel training on the technological students need to be solved.

Quality evaluation is an important method for enterprises and colleges to evaluate the overall quality and ability of employees and students, there is a lot of research for students' ability evaluation model, as well as for employees. But there is no evaluation model link the two key periods. With the development of the concept of quality education and the deepening in practice, the concept and method of students' quality evaluation should also keep pace with times \cite{4}.
Therefore, this article has carried on the systematized research and the summary to this question. Based on the competency model of college students, a talent growth coordinate system is constructed. Its purpose is to integrate the three party evaluation standard, this system covers all the factors related to talent in the learning and working period, By combining with the investigation and analysis of the related characteristics of talents demand unit analysis and result to establish a comprehensive social talent demand, colleges teaching objectives, students' self-cognition and personality characteristics of the growth of coordinates, and according to the characteristics of each student to determine the assessment point in space multidimensional coordinate system, the use of self-cognition and evaluation the employer demand for talent and students to achieve balance and unity, the establishment of a unified multidimensional coordinate provided an effective evaluation method for graduates in universities and enterprises.

2. Research on competency model of Technological College Students

2.1 Competency quality
The competency means it’s able to distinguish with outstanding achievements and a mediocre work in the personal characteristics [5]. Competency definition usually refers to the excellent performance with the knowledge, skills, abilities and qualities [6]. Some researchers believe that competence is the key characteristics of the employees' values, motivation, personality, attitude, skill, ability and knowledge in working situation [7].

2.2 Construction of competency model for Technological College Students
The competency quality of technological college students not only includes the universality of the quality of college students, but also the particularity of Technological students. Competency is able to distinguish between personal characteristics of the level of performance in a specific job and organization environment [8].

The competency model of technological college students has the characteristics of industry and enterprise, which has the characteristics of multi dimension and hierarchy. The quality cultivation of technological students is divided into 5 specific categories and several basic elements, including morality, basic ability, research ability, professional skills and subject knowledge, which are under the overall framework of morality, intelligence and physique, Including the understanding of technological on the environment, environmental protection and sustainable development consciousness, occupation morality, sense of responsibility, adhere to the spirit and independent spirit, research and practice ability, find and solve engineering problems, put forward and application of modern computer tools.

3. Construction of talent growth coordinate system based on competency model of Technological College Students

3.1 The definition and connotation of talent growth coordinate system
This paper study on the competency model of technological students, has established students competency evaluation model based on educational objectives and the employment needs [9]. And on this basis, put forward the concept of talent growth coordinate system, and provide visual methods to grasp the students' growth trajectory from the quantitative point of view. The talent growth coordinate system realizes the integration of two evaluation standards in social and school levels to a certain extent, and takes into account the personal quality growth process, draw "Enterprise Demand", "Personal Development" and "Teaching Objectives" together, as shown in fig. 1.
3.2 The selection of core evaluation elements in talent growth coordinate system
Through the investigation and research, this paper summarizes the characteristics of 10 employers' requirements based on the interviews. The demand characteristics of employers for graduates: professional level, psychological adjustment ability, basic quality level, personal basic information, basic practical ability, innovation ability and knowledge expansion ability etc. The analysis of the characteristics of these needs can effectively reflect the employers’ demands on graduates’ professional ability, social ability, team work ability, stability and development space.

As shown in Fig 2, in the space coordinate system composed of Enterprise Demand, Personal Development, and Teaching Objectives, establishing the multi dimension individual talents coordinate system with ten core elements of evaluation. In each main factor, there may be subdivision factors. These segmentation factors, as the lowest evaluation index, constitute the whole index system to evaluate the effect of Technological education. The specific sub factor evaluation is derived from the feedback from the students during their studies.

3.3 Construction of evaluation index system of talent growth coordinate system
The evaluation model of technological education effect based on ANP [10], and the evaluation index system including 20 elements are obtained according to the coordinate system. The following are the 20 indicators and their relationship:
- C1: learning initiative:
  - C11: educational activities;
  - C12: recreational activities;
  - C13: academic performance;
C2: practical ability and basic skills;
   C21: practical innovation evaluation;
   C22: practice course score;
C3: development ability and career planning ability;
   C31: career planning;
   C32: self-understanding;
   C33: social status;
C4: teamwork awareness and ability;
   C41: team evaluation;
   C42: student work experience;
C5: adaptability;
C6: independent working ability and analytical problem solving skills;
   C61: academic activities;
   C62: engineering practice results;
C7: psychological quality;
C8: innovation consciousness and ability;
   C81: innovation experience;
   C82: creative score;
C9: professional knowledge;
   C91: professional courses;
   C92: academic achievements;
C10: social responsibility and moral accomplishment;
   C101: social work;
   C102: moral character.

3.4 Construction of talent growth coordinate system

This paper adopts the analytic hierarchy process as the main evaluation methods \[11\], take the comprehensive evaluation factor as the target layer, and take the "growth factor" as decision-making layer. By means of collaboration with teachers and students, the relation between data index and growth factors at each period of the school period is obtained. It is defined as the bottom of the index system the index layer, and the index weight is determined according to the density of the relation.

Using network analytic hierarchy process to build the coordinate system of talent growth steps are as follows:

1. Describe the evaluation problem as a network structure, define the objectives, criteria, elements, and relationships among them in detail, and analyze them, aiming at the definition of the target, combining the Delphi method \[12\], the evaluation criteria \( P \) and the index element \( e \) are obtained. Then, the matrix \( A \) between elements is determined by brainstorming method \[13\]. Then links between network elements are established. The matrix element \( a_{ij} = 1 \) represents the element \( i \) and has an effect on the element \( j \).

2. The construction of the pairwise comparison matrix between elements

In order to construct the relative importance of different elements to the target under different criteria, this paper adopts Saaty's Fundamental Scale \[14\] as the advantages of the value of the scale, 1 indicates that the two elements have the same degree of importance, and 9 indicates that one element has an extremely significant influence on the other element, and the inverse is used as an inverse comparison between the strengths of the elements. Therefore, the value of the advantages of scale shown as table 1:
In order to ensure the reliability and consistency of pairwise comparison matrices in subsequent evaluation processes, the Saaty definition of consistency index (CI) and the random consistency ratio (CR) formula are as follows:

\[ CI = \frac{\lambda_{max} - n}{n-1} \]

\[ CR = \frac{CI}{RI} \]

\[ \lambda_{max} \] means the maximum eigenvalue of the comparison matrix, \( n \) is the number of elements, \( RI \) is the consistency index of the same order random judgment matrix. By comparison matrix consistency with \( CR < 0.1 \), for the matrix order greater than \( 3 \times 3 \), the consistency of the matrix is acceptable while, if the judgment matrix deviation is too large, it should be considered to determine the correct.

### Table 2. Reference table of RI value under different order.

<table>
<thead>
<tr>
<th>orders</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
</tr>
<tr>
<td>4</td>
<td>0.89</td>
</tr>
<tr>
<td>5</td>
<td>1.12</td>
</tr>
<tr>
<td>6</td>
<td>1.26</td>
</tr>
<tr>
<td>7</td>
<td>1.36</td>
</tr>
<tr>
<td>8</td>
<td>1.41</td>
</tr>
<tr>
<td>9</td>
<td>1.46</td>
</tr>
<tr>
<td>10</td>
<td>1.49</td>
</tr>
<tr>
<td>11</td>
<td>1.52</td>
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<td>12</td>
<td>1.54</td>
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<td>13</td>
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<td>1.59</td>
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<td>16</td>
<td>1.5943</td>
</tr>
<tr>
<td>17</td>
<td>1.6064</td>
</tr>
<tr>
<td>18</td>
<td>1.6133</td>
</tr>
<tr>
<td>19</td>
<td>1.6207</td>
</tr>
<tr>
<td>20</td>
<td>1.6292</td>
</tr>
</tbody>
</table>

### Table 3. Normalized eigenvector.

<table>
<thead>
<tr>
<th>( C_i )</th>
<th>( C_1 )</th>
<th>( \ldots )</th>
<th>( C_n )</th>
<th>Normalized eigenvector</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_1 )</td>
<td></td>
<td></td>
<td></td>
<td>( d_{i1} )</td>
</tr>
<tr>
<td>( \ldots )</td>
<td></td>
<td></td>
<td></td>
<td>( \ldots )</td>
</tr>
<tr>
<td>( C_n )</td>
<td></td>
<td></td>
<td></td>
<td>( a_{ij} )</td>
</tr>
</tbody>
</table>

Therefore, the weight matrix \( A \)

\[
A = \begin{bmatrix}
  a_{11} & \cdots & a_{1n} \\
  \vdots & \ddots & \vdots \\
  a_{n1} & \cdots & a_{nn}
\end{bmatrix}
\]
Then, in order to evaluate the mutual influence of the underlying elements, a super matrix is constructed. Suppose \( e_{i1}, e_{i2}, \ldots, e_{in} \) \((i = 1, 2, \ldots, n)\) in \( C_i \), take the control layer element \( p_s (s = 1, 2, \ldots, m) \) as the criterion, set a group of elements \( e_k (k = 1, 2, \ldots, N_i) \) as target, compared with other elements of the dominance of judgment according to its influence on \( e_k \), the structure as shown in Table 4.

Table 4. Judgment matrix.

<table>
<thead>
<tr>
<th>( e_k )</th>
<th>( e_{i1} )</th>
<th>( \ldots )</th>
<th>( e_{in} )</th>
<th>Normalized eigenvector</th>
</tr>
</thead>
<tbody>
<tr>
<td>( e_{i1} )</td>
<td>( \ldots )</td>
<td>Judgment matrix</td>
<td>( \omega_{i1} )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>( e_{iN_i} )</td>
<td>( \omega_{iN_i} )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The matrix \( W_{ij} \) is defined as the matrix of the normalized eigenvector of the matrix to determine the relative influence of all elements \( C_j \) on all elements \( C_i \).

\[
W_{ij} = \begin{bmatrix}
\omega_{i1}^{j1} & \cdots & \omega_{i1}^{jN_i} \\
\vdots & \ddots & \vdots \\
\omega_{iN_i}^{j1} & \cdots & \omega_{iN_i}^{jN_i}
\end{bmatrix}
\]

We can obtain \( W_{ij} = 0 \) if the element \( C_i \) is not affected by the element \( C_j \). Because the number of element group is \( n \), so the number of matrix is \( N^* n \), these matrices are arranged in sequence into a block matrix, the super matrix \( W \) is obtained, the expression is.

\[
W = \begin{bmatrix}
W_{11} & W_{1n} \\
W_{n1} & W_{nn}
\end{bmatrix}
\]

Since each \( W_{ij} \) is a normalized or zero matrix, \( W \) is a nonnegative matrix, but not a normalized one. The weighting matrix is weighted to obtain the weighted super matrix \( \bar{W} \). The weighted result of each block matrix is \( \bar{W}_{ij} = a_{ij} W_{ij} \). Finally, the weighted moment matrix is obtained as 1, and the following matrices are expressed as a weighted super matrix \( W \) for simplicity.

4. Calculate the final element weight

Finally, according to the theorem, when a layer of internal circulation system dependence, the super matrix squaring limit, and each column is the eigenvector corresponding to eigenvalue normalization. Finally, the matrix \( W^\infty \) is obtained and called the limit matrix, and the limit matrix corresponds to the value of each column.

3.5 Model weight calculation

In this paper, according to the comprehensive evaluation index system of college education, use Super Decision software to realize the ANP method. After constructing the ANP model, use Delphy method to determine the dominance of each element. In this paper, the evaluation result of a certain criterion of engineering education is the only factor we concern; thus, the target and criterion in the control layer are 1. When the importance comparison between \( C_1, C_2, \ldots, C_{10} \) is finished, Super Decision software can automatically generate the weight matrix. After all the elements are compared with each other, the software is used to generate the super matrix. Then, the weighted matrix is computed by multiplying the weight values in the weight matrix with the corresponding elements in the super matrix. Finally, the limit matrix of the weighted super matrix is obtained, and each column is normalized, as shown in fig 3.
4. Data acquisition and processing and result analysis

4.1 Data acquisition and processing

The data mainly come from the questionnaire survey and the data of the students in Beijing Institute of Technology. Due to the differences in the learning basis of grades, subjects, colleges and so on, there are also differences in the number of students for different indicators. Because this paper only considers the evaluation of the effect of technological education, it can ignore the effect of random disturbance.

Finally, this paper analyzes the data to determine the value of each index, and obtain the weight by ANP method. Evaluate the effect of technological education in Beijing Institute of Technology for six semesters in three years, and to determine the overall quality of students in these years.
4.2 Result analysis

4.2.1 The average value of the effect of technological education in terms of semester

Figure 4. Average value of Engineering Education in different semester.

Taking Beijing Institute of Technology as an example, the project education at this stage includes the basic theory education of the project, the practice education inside and outside the school and the extracurricular scientific and technological innovation activities of the students. According to the analysis and survey data of 3.4 and 3.5, the practical ability and skills (C2) quantitative parameters as effect of technological education, the distribution of the scores of each semester is obtained after quantifying the effect of Technological Education, as shown in fig 6. It can be seen that, in terms of the final score, the effect of technological Education in the fourth semester has a greater setback, but in the subsequent two semesters has improved. The current training program cannot achieve the goal of obtaining students' uniform and orderly training of engineering practice ability, Therefore we suggest that school reasonable improvement fourth semester course structure, take measures to improve the quality of education in the fourth semester, to avoid the lack of practice education and the cultivation of students' ability of engineering practice of the discontinuous problem.

4.2.2 Different employers' preferences for the growth of the coordinate system

This paper has been divided into the following 5 types of enterprises: state owned enterprises, institutions, private enterprises, foreign enterprises and other enterprises. Calculate the scores of the ten main factors of each nature of the enterprise, and then compare the different nature of the company's ability to graduate preference and focus. Different employers' preference analysis of the coordinate structure of talent growth can help the employment guidance departments of colleges and universities carry out employment guidance according to their abilities and personality characteristics.

4.2.3 The nature of enterprise matching with different growth coordinates

This paper analyzes the matching degree of different students' ability and quality elements to the needs of different types of enterprises, the results shown in Fig.5. The matching degree between the ten quality elements and the enterprise is obtained by quantizing the values as shown in the ordinate, and the higher the value, the more matching the quality of the enterprise. Through the analysis of different growth coordinate matching enterprise, graduates can match their own abilities and qualities to the types of enterprises that are best suited to their own development, it will help students maximize their abilities in their careers.
5. The application of the coordinate system of talents training for Engineering College Students

After the formation of growth coordinate system, it is the next research goal to seek the conjunction point of educational resources and growth coordinate system. This paper proposes a dynamic evaluation system of talent growth coordinate. In the future research, the analytic hierarchy process can be used as the main evaluation method, the comprehensive evaluation factor as the target layer, and the "growth factor" as the target layer under the layer, decision-making layer, relationship between teachers and students through the period of cooperation are in each period of data index and the "growth factor", which is defined as the bottom of the index system, index level, index the weights are determined according to the relationship of density. The change of the growth coordinate system is reflected on the time axis to form a dynamic personal growth track map, as shown in Fig 6. In the talent growth coordinate system, we can see the value and change of a certain quality evaluation factor in different grades and growth stages in time.

![Figure 5. Different growth coordinates matching different enterprises.](image)

![Figure 6. Personal growth model in the coordinate system of talent growth.](image)

The changes in the environment, inevitably lead to changes in the assessment of talent indicators, the growth of coordinate system reflects in this talent quality changes over time. In order to draw up the evaluation index of talents based on the same standard, this paper puts forward the dynamic evaluation index system of talent quality in students' period. In this paper, the dynamic growth evaluation time of talents is assumed to be unit.
6. Conclusion

Based on the theoretical foundation of Competence Model and a thorough analysis of such model for technological college students, the article was built the Talent Growth Coordinate System, namely an index system for students’ competency with three mutually integrated facets. This paper analyzes the data to determine the value of each index, and obtain the weight by ANP method. Evaluate the effect of technological education in Beijing Institute of Technology for six semesters in three years, and to determine the overall quality of students in these years.

7. References