Research on the Key Factors of Engineering Doctoral Enrollment Objects Based on Vague Value

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Abstract. Scientific and rational selection of engineering doctoral students is the key to cultivate high level engineering and technical personnel. Because of there is no clearly defined engineering doctoral enrollment objects degree, age and work experience, and there is no requirement for students of foreign language proficiency and master's thesis, engineering doctoral enrollment object selection has become a hot social concern. In this paper, we build the evaluation index set of the engineering doctoral enrollment target based on Vague set, and find out the key index of the engineering doctoral students enrollment and analysis.

Introduction

At present, how to solve the problem of China's high level technical personnel shortage is the most important part of our country's enterprises to improve innovation ability and international competitiveness. How to solve this problem, cultivate high-level engineering and technical personnel and related areas of high-end leading talent, are the most urgent task placed in front of China's higher education.

In order to train more the compound talents who can improve the ability of national innovation, The Education Department of our country has revised and improved the training program. And it was approved by the twenty-eighth meeting of the State Council of the State Council in 2011 on the establishment of a doctoral degree in engineering.

In the "engineering doctoral program", it mentioned that with a master's degree is a necessary condition for each candidate to become a doctor of engineering. At the same time, the enrollment of engineering students should have a high demand on the theoretical basis and engineering practice ability of the students. The State Council passed the "notice on the relevant issues concerning the pilot work of the professional degree graduate education of the engineering doctor". The notice stressed that the engineering doctorate enrollment and training work need to be carried out according to the national science and technology projects. The enrolled students are required to participate in national science and technology research in a substantial way, and also have the potential to be an important part of the engineering technology leader.

In 2012, national engineering doctoral candidates for the number of 581 people, and the enrollment target evaluation and selection of 243 people, the proportion was 2.39:1.25 pilot colleges and universities than the admission ratio has a great difference, the highest reached 8:1, while the smallest is only 1:1. At the same time, due to the different requirements of the various pilot colleges and universities enrollment target, leading to the number of primary election in each pilot colleges and universities is largely different. And, by comparing the number of enrollment plans and the final number of actual enrollment, there are some colleges and universities more than the actual number of enrollment.

In addition, since the State Council Academic Degrees Office did not specify the degree and work experience of the doctoral candidates, there was no specific requirement on the foreign language level and the thesis. At present in the engineering doctoral training process, there existed enrollment phenomenon "turn on the water", therefore, candidates mixed diploma chaos often occurs. This has resulted the real national major projects of important people cannot enter, and this...
make there exists a big gap with the original intention of the degree of professional doctorate in engineering. As a result, the object of doctorate enrollment has become a hot issue of social concern. Scientific, reasonable and objective evaluation and selection of the object of doctorate admissions become more complex and are particularly important.

At present, the research results mainly focus on the prospectus of engineering doctoral degree graduate students, take the development of engineering doctoral education as the starting point, and optimize the research of doctoral training objectives, course system, training mode and dissertations, etc, and finally putting forward relevant thinking and suggestions for training mode. In this paper, the selection of engineering doctoral candidates has become the focus of the pilot training.

**Establishment of Evaluation Index System for Doctoral Candidates for Engineering**

The society's need for engineering doctorates has brought up the engineering training objectives. Engineering training objectives are: (1) has the originality, can make the contribution in the corresponding engineering domain and the enterprise development; (2) be able to quickly and keen insight into the progress of engineering and technology, and can exert influence; (3) to become a professional leader and organizer of the potential and quality, be able to adapt to the rapid changes in the market and have the ability to change production behavior.

**The Establishment of Evaluation Index System for Doctoral Candidates for Engineering**

The enrollment of engineering doctoral programs is the basis of engineering doctoral education, which is an important factor to ensure the quality of training. Therefore, in order to achieve the training objectives of the engineering doctor, we need to establish a rigorous evaluation index system for the enrollment of engineering doctoral candidates, strict selection of candidates, select the talent with engineering talent potential. The doctoral program for the project put forward more professional requirements. At present, the major pilot universities have to meet the needs of the community as the starting point for the Doctor of Engineering. Innovation and training programs, improves the engineering doctoral training system, and to ensure the quality of training have a great challenge.

### Table 1. Evaluation index for doctoral candidates for engineering.

<table>
<thead>
<tr>
<th>Index name</th>
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<tr>
<td>1 has received a master's degree</td>
<td>13 have the potential of engineering technology leader</td>
</tr>
<tr>
<td>2 engineering practice or training potential</td>
<td>14 Honest and trustworthy</td>
</tr>
<tr>
<td>3 Theoretical Foundation of Engineering Technology</td>
<td>15 correct style of study</td>
</tr>
<tr>
<td>4 undertake major national science and technology projects</td>
<td>16 academic behavior</td>
</tr>
<tr>
<td>5 scientific research ability</td>
<td>17 physical and mental health</td>
</tr>
<tr>
<td>6 professional knowledge</td>
<td>18 ability to practice</td>
</tr>
<tr>
<td>7 Foreign Language Level</td>
<td>19 Team Spirit</td>
</tr>
<tr>
<td>8 Innovation ability</td>
<td>20 years of age not exceeding 45 years</td>
</tr>
<tr>
<td>9 Comprehensive Quality</td>
<td>21 experts recommend</td>
</tr>
<tr>
<td>10 Engineering Specialist</td>
<td>22 working experience</td>
</tr>
<tr>
<td>11 Engaged in engineering and technical jobs</td>
<td>23 International Perspective and Cross-Cultural Competitiveness</td>
</tr>
<tr>
<td>12 has the engineering practice research results</td>
<td>24 Cooperation and interpersonal skills</td>
</tr>
</tbody>
</table>
The basic characteristics of engineering and technical personnel are mainly three aspects: thick foundation, the premise of the development of engineering doctorate is the basic theory of technical personnel; strong skills, engineering and technical personnel is an important feature of strong practical hands-on ability; operational capacity, Engineering and technical personnel of a strong sense of innovation to solve practical problems.

In summary, the higher engineering education enrollment object evaluation involves many factors, this article in the establishment of engineering doctoral admissions object evaluation index process, with reference to the 25 pilot university engineering doctoral enrollment brochure, getting a more complete engineering doctoral admissions object evaluation index, Table 1 above.

**Establishment of Index System of Key Factors**

A large number of studies show that the key factors in the establishment of index system need to be streamlined, taking into account the adverse effects of the cumulative errors and the requirements of the independence of each index. Furthermore, we must select the most important index in the evaluation index of the 24 engineering doctoral course system given by table 1, and establish a key index system.

For the selection of key indicators, the traditional approach is to let the experts sort on the importance of these 17 indicators, then gather the preferences of the experts to form a group preference, according to the group preference ranking deriving key indicators But in order to avoid the difficulties and contradictions of the expert scoring and sorting large samples, this paper proposes a selection method based on Vague sets, this method can reflect the experts’ judgment on each index "will seriously affect the engineering doctoral education" or "do not affect the engineering doctoral education", so it has a more intuitive significance, and is also very easy to use.

First of all, the basic concepts of Vague sets, namely:

Define 1 set U is a non-empty set, element $x \in U$. An Vague set A on the U is a pair of membership functions $t_A$ and $f_A$ on the U, that is,

$$t_A : U \rightarrow [0,1], \quad f_A : U \rightarrow [0,1].$$

Satisfying $t_A(x) + f_A(x) \leq 1$, and $0 \leq t_A(x) \leq 1, 0 \leq f_A(x) \leq 1$.

Among them, $t_A$ is used to show the lower bound of the membership degree of the supporting evidence. $f_A$ is a false membership function of Vague set A, which expresses against the lower bound of the membership degree of the evidence $x \in A$.

Define2 $x$ is vague value on the domain U, $x= [t_x, 1-f_x]$. Among them, $t_x \in [0,1]$, $f_x \in [0,1]$, $t_x + f_x \leq 1$, S(x) is kernel function, $S(x) = t_x - f_x$, $S(x) \in [-1,1]$ [6].

Then, the specific steps of the selection method based on Vague set are as follows:

1. **Expert evaluation.** Please n experts to judge the importance of each indicator $x_i$, that will seriously affect the performance of the engineering painting "V", that will not affect the performance of the Engineering Dr Painting "X", that cannot be judged painting "○". (In this paper, we take n=10, i=1, 2,..., 24)

2. **Calculation of the value of the true membership function $t_A$ and the false membership function $f_A$.**

The relationship of complete set U to the key index set A, $R(U \rightarrow A)$, is a Vague set relationship. $t_A(x_i)$ indicates that the index $x_i$ "will seriously affect the performance of the project" degree, $f_A(x_i)$ indicates that the index $x_i$ "will not seriously affect the performance of the project" degree.

$t_A(x_i)$= the number of experts who think $x_i$ seriously affects / the total number of experts n

$f_A(x_i)$=the number of experts who think $x_i$ does not seriously affect / the total number of experts n

Meeting the definition of $1,0 \leq t_A(x) \leq 1,0 \leq f_A(x) \leq 1$ and $t_A(x) + f_A(x) \leq 1$.

3. **Determine the value of the kernel function $S_A(x_i)$.**

$$S_A(x_i) = t_A(x_i) - f_A(x_i)$$  \hspace{1cm} (1)

here, $S_A(x_i)$ said that experts account for the proportion of the total number of experts ,who think the impact of the $x_i$ index serious is more than the impact of the index not serious, which reflects the
reliability of index $x_i$, "key elements of the engineering doctor training program", the greater $S_A(x_i)$, the greater the reliability, and as the weight of the subsequent calculation.

At the same time, given the importance index $\alpha$ ($0<\alpha<1$), when $S_A(x_i)\geq \alpha$, $x_i$ is selected set of key index A. In this paper, $\alpha=0.4$. That is, when the number of experts who think the $x_i$ will seriously affect the performance of the project more than 40% of the number of experts think it is not serious, $x_i$ is selected into key index set.

This paper selects 10 experts to judge the importance of 24 indexes in Table 1, and then follow the steps above to select 7 indexes marked ** as shown in Table 2.

Table 2. Selection of key factors index based on Vague set.

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| $e_{i(x)}$ | 1.85 | 0.46 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 |
| $f_{d(x)}$ | 0.52 | 0.01 | 0.02 | 0.03 | 0.04 | 0.02 | 0.01 | 0.02 | 0.03 | 0.04 | 0.02 | 0.01 | 0.02 | 0.03 | 0.04 | 0.02 | 0.01 | 0.02 | 0.03 | 0.04 | 0.02 | 0.01 | 0.02 |
| $S_{A(x)}$ | 1.08 | 0.76 | 0.68 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 | 0.52 | 0.63 | 0.53 | 0.62 | 0.73 |

By using Vague set theory, seven key indicators were selected from 24 comprehensive Ph.D. performance evaluation to determine the key indicators of PhD evaluation including the master's degree, engineering practice ability or training potential, theoretical basis of engineering technology, National science and technology major projects, scientific research ability, engineering technology leader with the potential, as well as seven elements of work experience.

Conclusion

It is often impossible to use clear and definite judgment language or accurate data in the study of the evaluation index of the object of doctoral admissions. Therefore, we consider the introduction of Vague set to determine the key index set. In this paper, there are some imperfections in the research on the index of graduate student enrollment, such as the influence of external factors when the experts scoring and so on need to continue to do work.

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References


