Analysis on the Needs of Engineers in Electric Power Industry for Continuing Engineering Education in China

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ABSTRACT
The authors conducted questionnaire surveys and interviews on the engineers in several enterprises in China from Sept 2012 to Nov 2013. The research investigated the continuing education of engineering graduates in these enterprises and analyzed the relationship between continuing education with career development. This paper summarized the characteristics of continuing education of the engineers in these enterprises and the relativity between continuing education and career development. The paper concluded with suggestions for higher education institutions, enterprises and training organizations to provide better services for engineers.

Keywords
Engineers, Continuing Engineering Education, Electric Power Industry, Empirical Analysis

INTRODUCTION
The electric power industry in China is a fundamental industry to support nation’s economic and social development. This industry is a public utility, with the goals to provide cleaner and more economic power, safer and more efficient configuration, more convenient and more reliable electricity for the economic
development and people's life in China. The engineers in electric power industry are the backbones to realize these goals. They need to have sufficient professional skills and expertise in specific areas to fulfill this special social responsibilities. To obtain these skills and expertise, they need long-term training and practice, for which continuing education plays an important role. The Institute of Education and the Center for Engineering Education in Tsinghua University initiated a research project on technology personnel training and conducted an empirical research to investigate the engineers' continuing education and training in the enterprises after graduation from universities. The characteristics of electrical engineers' continuing education and their relationship with career development were analyzed, with the aims to provide empirical evidence and suggestions for higher education institutions, enterprises, as well as training institutions to better meet the learning needs of engineers and improve customer service.

I. Research Design

1. Research Framework

The research chose three dimensions to observe the characteristics of engineers' learning needs: personal characteristics, working experience and learning experience. Personal characteristics largely reflected or influenced one's cultural background and professional ability. Work experience reflected engineers' career situation and employers' recognition of employees' labor value. Learning experience reflected engineers' learning situation, learning expectation and interests, learning abilities and habits, learning difficulties and so on. These three dimensions basically covered the main factors affecting the engineers' on-the-job learning and reflected the learning needs of engineers. Based on the above research framework, this study developed an interview procedure and a questionnaire, defined each dimension, and designed the index in each dimension.

The questionnaire consisted of three parts, with a total of 21 questions, including fill-in-the-blank, multiple choice and scale. The first part had 4 fill-in-the-blank questions, involving gender, age, graduation institution, degree level and major of the engineers. The second part consisted 2 fill-in-the-blank questions and 3 multiple choice questions, involving engineers' working time, professional titles, position level and the relevance between their jobs and their majors in universities. The professional titles were divided into junior, intermediate, senior and others. Positions were divided into entry level, middle level, high level and others. The third part included 10 multiple-choice questions and 2 scale questions, regarding the learning needs of engineers. The 2 scale questions in this part were designed to test the influence of education content to career and of institutions facilities to learning outcomes. The subjects were required to use a number between 1~5 to describe the influence of learning content (such as knowledge, skills and abilities), teaching facilities and faculty to themselves. The higher the score, the higher the degree of influence. After the test, the learning preferences and needs of the subjects were calculated.
2. Data Collection
During the period from September 2012 to November 2013, the research team visited and investigated 6 power enterprises and 2 Electric Power Research Institutes in the city of Beijing, Chengdu, Meishan, Xi'an, Xiamen and Wuxi. 8 people who were responsible for enterprises' education and training and 14 engineers were interviewed. At the same time, with the approval of enterprise's human resources department, the team conducted questionnaire surveys, using convenient sampling method, among engineers. The questionnaire were distributed and withdrew on the spot. 908 effective samples were collected. The statistical characteristics of the samples were shown in table 1.

3. Data Analysis
The research objects of this paper were young and middle-aged engineers who had formal higher education, received bachelor or above degrees, and worked on the various positions in production line. Therefore the valid samples were selected based on the following criteria: the age between 25 to 55 years old; holding bachelor or above degrees; having junior, intermediate or senior professional titles; and having entry, middle or high level positions. IBM SPSS 19 software was used to make descriptive statistics and correlation analysis. The interview notes and recordings were analyzed. The learning needs of engineers were concluded based on the quantitative and qualitative study.

Table 1 Statistical Characteristics of the Samples (N=908)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Samples</td>
<td>617</td>
<td>291</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>68</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>25~34</th>
<th>35~44</th>
<th>45~54</th>
<th>其他</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Samples</td>
<td>508</td>
<td>204</td>
<td>103</td>
<td>57</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>59</td>
<td>27</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Degree obtained</th>
<th>Bachelor</th>
<th>Master</th>
<th>Doctor</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Samples</td>
<td>400</td>
<td>218</td>
<td>18</td>
<td>272</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>44</td>
<td>24</td>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Professional Title</th>
<th>Junior</th>
<th>Intermediate</th>
<th>Senior</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Samples</td>
<td>309</td>
<td>354</td>
<td>136</td>
<td>109</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>34</td>
<td>39</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position Level</th>
<th>Entry Level</th>
<th>Middle Level</th>
<th>High Level</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Samples</td>
<td>527</td>
<td>163</td>
<td>36</td>
<td>182</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>58</td>
<td>18</td>
<td>4</td>
<td>20</td>
</tr>
</tbody>
</table>


III. Characteristics of Engineers’ Learning Needs

The overall results of the investigation and statistics showed, 88% engineers believed the continuing education in the enterprises had positive influence to the promotion of titles and positions; 77% engineers believed that the current education training and self-study situation could meet the needs of personal career development; 58% engineers had regular salary during the study period. There were no significant differences between male and female engineers on the above findings. These findings indicated that engineers had recognitions on the training systems in the enterprises. Engineers and enterprises had reached a consensus on the importance of education and training as education and training being a necessary strategy for the development and talent reservation of enterprises.

1. strong learning desire and clear learning goals

To build modern enterprises with core competitiveness, electric power enterprises had established an integrated talent incentive mechanism which included talent training, assessment, employment and development, creating a good environment for talents development. In this context, engineers, as the representatives of advanced technology and the backbone of enterprises’ development, showed a strong desire for learning. Their learning targets were clearly manifested as to obtain a degree or diploma through formal academic education, or improve the professional skills through the occupation training. As shown in Figure 1, 60% engineers expressed strong desire for education and 81% thought there were needs to participate in professional training to improve their professional skills. Among the 908 valid samples, 70% engineers had received formal higher education and had certain professional background. They were recruited to the enterprises through rigid selection. However, the correlation between their majors in higher education and working positions were significantly different. As Figure 2 showed, only 8% engineers engaged in the work completely related to what they had learnt, 67% somewhat related, and 25% completely unrelated.

![Fig 1 Percentage of Engineers’ Need for Academic Degree Education and Non-Degree Education](image-url)
In 1974, Klus used quantitative method to analyze the relationship between engineer’s working performances with continuing education. The results suggested the involvement of continuing engineering education had a positive impact to engineer’s occupation development and salary increase. [1] The result of this research confirmed and enriched Klus’s conclusion, namely the continuing education had positive impact to engineers’ development. First of all, the engineers could improve their working abilities through continuous learning and obtain more promotion opportunities, so as to increase their income and improve the life quality. Although it was difficult to quantify the economic benefits of continuing engineering education, continuing engineering education surely had yield rate. Secondly, formal higher education was not enough for engineers to interpret or solve problems in practical work. Li (2011) has also found through empirical study that poorly-prepared professional knowledge in higher education would significantly increase the over-education rate after they got employed. [2] Finally, along with China’s adjustment of industrial structure and the progress of science and technology, enterprises” production mode, management mode, development strategy were constantly changing, which had higher demands for engineers. Engineers could only improve their competence through professional learning.
2. Difference in the needs for learning content and level

As engineers involved in various professional fields and had different personal characteristics and occupation experience, their needs for learning content and level were different. Samples in various age groups had significant differences in demands of philosophy, humanities knowledge, professional knowledge and skills, occupation attributes, cognitive and communication abilities (Fig. 3). Samples with various education background had significant differences in demand of professional knowledge and skills (Figure 4). And samples with various titles had significant differences in demand of occupation attributes, cognitive and communication ability (Figure 5).

![Fig 3. The Mean Value of Learning Contents (Comparison by Age Groups)](image)

The international engineering community had already had some common views on the structure of engineers’ knowledge and abilities and proposed many engineer competence models, like John (2009)’s Engineer Leadership Model [3] , Mo Wen (2010)’s Engineer Attributes Tetrahedron [4] and Engineer Competence Framework proposed by Brenda (2011) [5]. However, the reasons for the differences of engineers’ learning contents should not be ignored. First of all, the higher education and the knowledge structure of the program, had decisive role in the formation of engineers’ knowledge structure. Engineering education prepared students initially have the basic attributes of engineers [6]. Secondly, the knowledge and skills of engineers were changing in different career stages. The research data indicated young engineers wanted to learn more and wider variety of knowledge and skills. Finally, the certification criteria of engineers not only regulated the entry qualification into engineer profession, but also reflected the level and grade of engineering profession: the requirements of professional attributes and abilities for higher level and grade engineers were higher.
3. Personalized Preference on Learning Style, Time and Location

Engineers’ learning activities reflected the special characteristics of adult learning. Their work experience, life experience, learning experience would continuously accumulate over time. Their learning needs emphasized the integration with individual experience. They hoped to choose the most appropriate learning styles, time and location according to their existing knowledge experience and behavior. Figure 6, 7 and 8 indicated the different choices of engineers in different age groups for learning style, time and location.

For learning style, classroom teaching was the most commonly used methods. Engineers at the ages of 25 ~ 34 and 45 ~ 54 showed great interest in returning
classroom. Discussions through which engineers could obtain new understandings or solutions to engineering problems was welcomed by 35 ~ 44- year old engineers. It was also found in the investigation that the apprentice mode matched the learning needs with intensive learning style and eased the contradiction between working and learning. It was more effective for young engineers to become familiar with the working environment and obtain working experience. In addition, compared with traditional learning styles, remote network learning had advantages breaking the limitations of time and location and reduce learning cost, but was not attractive to engineers. This might be related to the characteristics of industry, network facilities and engineering profession’s nature.

Fig 6 Samples’ Choice for Learning Style in Various Age Groups

Fig 7 Samples’ Choice for Learning Time in Various Age Groups

For learning location, higher education institutions were the first choice for
engineers. High-quality educational resources and good teaching environment were the advantages of higher education institutions. Young engineers preferred enterprise on-site learning. This experiential teaching method could train their consciousness and improve their work efficiency.

Fig 8 Samples’ Choice for Learning Location in Various Age Groups

4. Learning contradicted with working and time cost ranked first

In order to obtain the desired learning outcomes, engineers needed to overcome many difficulties, including tuition, time and labor costs. As shown in Figure 9, Chinese engineers in power industry had many difficulties in continuing education activities. The most difficult 3 factors were time cost, working pressure and expense.

Fig 9 Engineers’ Difficulties in Continuing Education
Time management theory indicated that time was a kind of special resources which could not be stored; was scarce and easily disappeared; had no substitutes; and whose supply was completely inelastic. [7] People in modern society paid increasing attention to the time value. First of all, on the time assignment, engineers needed to consider many factors. The surveyed enterprises basically adopted position appointment system. Engineers took great responsibility at working time and most of them had to support their own families. Therefore, except the working hours that enterprises arranged for intensive training and on-site training, engineers had to use their spare time for learning. How to spare enough time and effort for learning became the greatest practical problem for engineer. Secondly, they were facing the problem of learning efficiency. As their ages grew, ability of memory, perception and other intelligence performances began to decline. They were also lack of confidence and easily got inertia. And as many other objective reasons, such as the teaching content and arrangement, they could not get best result of their learning in specific time period and felt a waste of time, which reduced the value of learning.

In short, modern engineers' learning needs had the characteristics as urgency, differentiation, individuality, and continuity. And engineers also had many difficulties in learning. Therefore, continuing engineering education providers should pay more attention to characteristics of engineers' learning needs and provide a full range of educational services to benefit both the individuals and the society.

IV. Recommendations for Continuing Engineering Education

The characteristics of engineers' learning needs indicated that continuing engineering education for engineers was no longer a simple training, but an ability-construction system. The system not only involved the education institutions, but also had extensive and close contact with government, enterprises, industry associations, social organizations and other social systems. Based on the in-depth understanding of engineers' learning needs, the education providers should build relevant organization and management mechanism to enhance engineers' competence and abilities and enable them to realize their own values, create enterprise value and promote the progress of science and engineering technology.

1. Engineers' personal career development was an engine to continuing engineering education

Based on Maslow's hierarchy of needs theory, Joseph proposed engineers' learning needs theory in 1978, constructing the hierarchy of engineers’ needs. He believed that the needs of most engineers could be divided into two levels: esteem needs and self-realization needs. Continuing education institutions should focus on both levels [8]. For modern engineers, working was not only the means of making a living, but an experience to establish personalities, inspire their potentials and realize their own values. They needed continuous learning to renew their professional knowledge,
improve their skills and abilities and promote their career development. Therefore, the personal career development of engineers was an engine to engineering education.

Continuing engineering education institutions should provide learner-centered educational services for engineers. The personalized and diversified characteristics of engineers’ learning needs required the diversification of education; the characteristics of periodicity and the lifelong learning determined the sustainability of education services. Therefore, the institutions should regard the learners (engineers) as customers and conduct research on their learning needs. The cost and accessibility of learning should be considered. The idea of learner-centered education should be implemented in all aspects of education and training activities. On the one hand, institutions should provide a more rapid and thoughtful education service to attract and retain more customers. On the other hand, institutions should reduce operating costs by managing the business process. They should not only provide knowledge and skills training, but also build their brands and core values, so as meet the needs of customers. They could establish customer club, provide relevant follow-up services and value-added services and help engineers build their learning, living and friends networks.

2. The incentive mechanism of enterprises was the driving force of Continuing Engineering Education

Engineers were usually affiliated certain enterprises, which formed an official organizational foundation for the continuing education. Engineers were also affiliated to engineering associations or professional societies, which were informal and nonprofit organizations. These organizations were playing an important role in coordinating the relationship between government, enterprises, and engineers, maintaining engineers’ rights and interests, and providing professional services. They provided advantageous support to engineers’ continuing education. Enterprise were the main body of continuing engineering education, and also an influence on the effective implementation. Enterprises could promote the rational distribution, employment and mobility of engineers, and motivate engineers to enhance their capability and competence. Therefore, the incentive mechanism of enterprises was the driving force of continuing engineering education.

The key industries and large and medium-sized enterprises in China were highly recognized the importance of continuing education to the development of engineers’ career, development of enterprises and the implementation of the strategy. The vast majority of engineers had continuing education. Large state-owned enterprises had already established training and education systems based on engineers’ competency model and performance management. Enterprise universities, which were funded by enterprises became a form of education innovation and had rapid development in the country. However, there were still had many concerns on enterprises’ education and training systems, such as the quality of teaching, the contents of the training. In addition, small and medium-sized enterprises and private enterprises had a lot of
difficulties in continuing education, as they had few social resources and weak attraction for the talents. They mainly relied on industry associations and social training institutions to provide education and training for their small number of engineers. Association and social training institutions should provide engineers in small and medium-sized enterprises and private enterprises with special designed training programs.

3. Management system of engineers was a binding force for continuing engineering education

The development of society and the progress of technology had increasingly high requirements on the professional level and abilities of engineers. As the result, the occupation of engineer became more and more irreplaceable. A strict management system was the foundation of the engineer profession and a guarantee the profession’s status and monopoly. The regulations on engineers’ right and obligations could ensure the profession’s overall quality. The standardized and authoritative engineer certification and qualification system required high quality education and training for engineers. The socialized and specialized engineer management system could increase engineers’ labor value and public recognition. Therefore, engineer management system formed a binding force for continuing engineering education.

Although continuing engineering education institutions had rapid development in recent years, the development was not balanced and the level of education institutions were uneven. Continuing education was blamed to be useless or poor quality, which restricted the further development of education institutions. The construction and development of continuing engineering education institutions were related to the engineer qualification system. The linkage of continuing education, professional qualifications and promotion with the occupation development, could form a benign cycle of the supply and demand of engineers. The standardized development of continuing engineering education, could norm and constraint the educational institutions and guide them to improve the quality and management.

4. Funding for engineers’ learning was the continuing vitality of engineering education

Engineers’ education funding system was principally a cost sharing between government, enterprises and individuals. Government invested in infrastructure and public training platform; enterprises provided 1.5% to 2.5% of the total wages of engineers for their education funds; individual engineers voluntarily participate in continuing education. However, due to the professionalism, high investment and high operation and maintenance cost of continuing engineering education, survival and development of education institutions adequate human needed sufficient material and financial resources. Therefore, funding for engineers’ learning was the continuing vitality of engineering education.
The education institutions were facing the challenge of limited education funding. They should expand the financing channels, absorb social funds and encourage social organizations to participate in continuing education activities. The challenge could be overcome through a diversified investment mechanism with cooperation among government, enterprises, society and individuals. Secondly, neither of universities, enterprises, social organizations could undertake the engineers’ training task alone, they should form their own advantages and characteristics to meet the diverse learning needs of engineers. Finally, to ensure the sharing and integration of education resources, there should be a resource sharing mechanism and credit transfer system to form an "overpass" in engineers' continuing education.

CONCLUSIONS

Globalization, environment and resources issues had brought new challenges and opportunities to the education of engineers. There was no single organization can cultivate skilled and high quality engineers alone. Enterprises, higher education institutions and other continuing engineering education providers should work together and form a close cooperation to provide customer management services to engineers.

Analysis of interviews and questionnaire and the results of the research proved it a successful empirical investigation. However, there were still some deficiencies in the investigation and data process which needed further improvement.

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