Research on FCE-based Innovation and Entrepreneurial Ability Cultivation among Civil Engineering Majors

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Abstract

In recent years, with China’s economy under rapid development, stricter requirements have been set on the innovation and entrepreneurial ability (“IE ability”) of college graduates. However, there are still many shortcomings with IE ability cultivation among civil engineering majors, which has worsened the grim employment situation of college graduates. In view of the situation, the paper, adopting fuzzy comprehensive evaluation (“FCE”) method, puts forward such approaches as adopting a multi-level FCE model to evaluate graduation design quality, constructing and implementing innovation and entrepreneurship training projects, establishing a multidimensional practical teaching system and setting up a reasonable innovation and entrepreneurship curriculum system. The cultivation approaches proposed in the paper can help mobilize the initiative of civil engineering majors, develop and enhance their innovation and entrepreneurial awareness and ability, and dramatically improve the quality of IE ability cultivation among civil engineering majors.

Key Words: Civil Engineering, College Students, IE Ability, Cultivation.

1. RESEARCH BACKGROUND

1.1 Literature review

At present, grim employment situation is confronting the majority of civil engineering majors, but there is a lack of talents in this field in China. The underlying cause for the conflict is the gap between college student cultivation standards and standards for college graduates set by employers. China now has a great demand for comprehensive civil engineering talents that have practical ability, innovative ability and entrepreneurial potential. By far, researchers have done much research on cultivation of innovation and entrepreneurial ability (“IE ability”) among civil engineering majors. For example, Zhang Tianmei and some researchers, based on quality characteristics of civil engineering majors, established an innovation and entrepreneurship (“I&E”) curriculum system that is centered on IE ability cultivation and integrates three modules (i.e. classroom teaching, practical teaching, and second classroom), which enables I&E education to run through the entire teaching process (Zhang et al., 2012). Du Guofeng and some researchers believed that practitioner cultivation model based on school-enterprise cooperation and elite cultivation model based on academic competitions were of great significance to cultivating IE ability among civil engineering majors (Du et al., 2016). He Yanhong and others discussed the establishment of an I&E curriculum system for civil engineering majors, and proposed that the I&E curriculum system of college students shall be established and improved from the following perspectives: I&E awareness, I&E basic knowledge, IE ability, and experience exchange, etc. (He et al., 2016). Gu Yanling and others, according to the cultivation objectives applicable to colleges of applied sciences, believed that to build a faculty team, which have rich practical experience and comply with requirements for innovative talent cultivation, is also an effective way to enhance practical ability of students, namely, faculty members shall have relevant knowledge, practical experience, systematic course theories, and the ability to teach the courses (Gu and Sun, 2016). Yu Pei and others also conducted research on reform, innovation and development orientation of talent cultivation model for civil engineering majors (Yü et al., 2016).

1.2 Research purpose

Under the new economic normal, the number of college graduates has been on the increase. Therefore, great attention has been paid to IE ability cultivation among civil engineering majors. The paper discusses the approaches for cultivating IE ability among civil engineering majors, with a view to eliminate the shortcomings
with traditional cultivation approaches and enhance the IE ability of civil engineering majors. To this end, the paper first analyzes existing problems with IE ability cultivation among civil engineering majors, such as boring I&E courses, inaccurate development orientation, etc., and then puts forward effective approaches for IE ability cultivation. The cultivation approaches proposed in the paper can equip civil engineering majors with strong practical skills, prepare them for work and effectively enhance their IE ability, which can lay a solid foundation for cultivating innovative and entrepreneurial talents who can meet the demands of the 21st century. Moreover, the research results of the paper can provide a reference for relevant colleges to cultivate IE ability among civil engineering majors.

2. PROBLEMS WITH IE ABILITY CULTIVATION AMONG CIVIL ENGINEERING MAJORS

2.1 Boring I&E courses

At present, I&E courses are quite boring as they are set up at colleges according to the setup mode of specialized courses, and rely heavily on the instructor to impart knowledge. Worse still, the curriculum system is not well-planned due to failure in reasonably integrating relevant I&E courses. Moreover, there is no effective evaluation system for I&E courses (Chen and Huang, 2014). Such I&E education fails to deepen the thinking of college students, let alone improve their practical skills. Now, many colleges have adopted I&E trainings for civil engineering majors every year, but students are not very interested in such trainings, and the trainings cannot blend in with their specialized courses. Above-mentioned activities for IE ability cultivation aren’t geared to social demands, and are divorced from the imparting of specialized knowledge and ability cultivation at colleges.

2.2 Inaccurate positioning of I&E education

Relevant colleges have failed to accurately define I&E education, and to combine imparting of specialized knowledge and I&E education, which results in poor effect of I&E education and low I&E awareness among students. Furthermore, during the teaching process, I&E education is confined to knowledge transmission, and puts theories before practice, leading to weak IE ability of students. Moreover, colleges have failed to work out a complete I&E education plan and to set clear objectives for such education, which erodes the role of school education. And teachers strictly adhere to the teaching syllabus, but pay no attention to cultivation of independence and IE ability (Fu et al., 2012). In short, the I&E education for civil engineering majors isn’t based on practical situation of the major, with simple knowledge structure and incomplete teaching system. As a result, the students are not so independent, unable to start a business according to their own features, with weak practical ability, and unable to tackle fierce market competition, which leads to entrepreneurial failure of many college students and graduates.

3. FCE-BASED IE ABILITY CULTIVATION AMONG CIVIL ENGINEERING MAJORS

3.1 Evaluating graduation design quality based on multi-level FCE model

Application of FCE can make the evaluation results more objective and fair, and effectively improve the innovativeness and initiative of civil engineering majors in graduation design (Ma et al., 2012), which can in turn enhance their IE ability.

3.1.1 The Multi-level FCE Model

During the evaluation process, FCE takes into consideration different factors that affect the quality of graduation design. The first step is to set up evaluation indexes, namely, \( U = \{ u_1, u_2, ..., u_n \} \) = \{topic quality, student ability, graduation design quality\}. Then, it is required to establish the set of comments for the evaluation indexes, namely, \( V = \{ v_1, v_2, ..., v_m \} = \{ excellent, good, average, pass, failure \} \).

Firstly, it is necessary to establish the quality evaluation index system for graduation design of civil engineering majors, and according to features of the major, choose secondary indexes which can be quantified. Then, as per the impact on rating exerted by each evaluation index \( u_i \) \( (i = 1, 2, ..., m) \), weight fuzzy subset \( A \) is determined, namely, \( A = \{ a_1, a_2, a_3, ..., a_m \} \) where, \( u_i \) refers to the weight of \( u_i \) in the factor set.
Secondly, it is assumed that the elevation index factor \( u \) has \( s \) secondary evaluation indexes, whose index set is \( u_\alpha = \{ u_{\alpha 1}, u_{\alpha 2}, ..., u_{\alpha s} \} \); moreover, their corresponding weight is \( A_\alpha = \{ a_{\alpha 1}, a_{\alpha 2}, ..., a_{\alpha s} \} \), where, \( a_{\alpha \alpha} \) refers to the weight of \( u_{\alpha \alpha} \) in \( u_\alpha \); and \( a_{\alpha \alpha} \geq 0 \), and \( \sum a_{\alpha \alpha} = 1 \).

Thirdly, the rating scale has \( n \) ratings, with the rating set being \( V=\{ V_1, V_2, ..., V_n \} \) = “excellent, good, average, pass, failure”.

At last, comprehensive evaluation is carried out on the \( m \) factors of each \( u \). The fuzzy relation from \( u_i \) to \( V \) is described via fuzzy matrix \( R_i \). Then, comprehensive evaluation score of the target is worked out according to the following fuzzy computational relationship.

\[
R_i = \begin{pmatrix}
  r_{11} & r_{12} & k & r_{1n} \\
  r_{21} & r_{22} & k & r_{2n} \\
  k & k & k & k \\
  r_{m1} & r_{m2} & k & r_{mn}
\end{pmatrix}
\]

\[
B = AR = (a_1, a_2, a_3, k, a_m) \begin{pmatrix}
  r_{11} & r_{12} & k & r_{1n} \\
  r_{21} & r_{22} & k & r_{2n} \\
  k & k & k & k \\
  r_{m1} & r_{m2} & k & r_{mn}
\end{pmatrix} = (b_1, b_2, b_3, k, b_n)
\]

where, \( r_{mn} \) refers to the membership degree of factor \( u_{i n} \) to Level \( j \) rating \( v_j \).

3.1.2 Application of Multi-level FCE Model to Evaluate Graduation Design Quality of Civil Engineering Majors

First, there is a need to determine the set of factors for the evaluation indexes. Based on FCE theory, the evaluation index system for civil engineering majors is then determined, as is shown in Table 1.

Second, it is required to decide the rating of each evaluation index. The set of comments for graduation design quality evaluation of civil engineering majors has five ratings, namely, \( v=\{ v_1, v_2, v_3, v_4, v_5 \} \) = {excellent, good, average, pass, failure}.

Finally, it is necessary to decide the weight set of evaluation factors. The weight set per index is shown in Table 1.

**Table 1 Factor Set of the Evaluation Index System for Graduation Design Quality**

<table>
<thead>
<tr>
<th>Primary index</th>
<th>Secondary index</th>
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<tbody>
<tr>
<td>Topic quality ((u_i=0.25))</td>
<td>The topic has practical research value and can demonstrate the student’s IE ability ((u_{ij}=0.25))</td>
</tr>
<tr>
<td>Workload ((u_{ij}=0.25))</td>
<td>Relevance to technology, production and lab construction ((u_{ij}=0.25))</td>
</tr>
<tr>
<td>Student ability (u_i=0.60)</td>
<td>The student’s ability to conduct a survey, and analyze and integrate information ((u_{ij}=0.15))</td>
</tr>
<tr>
<td>Well-arranged and sufficiently developed ((u_{ij}=0.22))</td>
<td>Ability to analyze problems ((u_{ij}=0.15))</td>
</tr>
<tr>
<td>Design innovativeness and uniqueness ((u_{ij}=0.15))</td>
<td>Compliance with applicable regulations on format, drawings, and experimental data ((u_{ij}=0.50))</td>
</tr>
<tr>
<td>Design quality (u_i=0.25)</td>
<td>Accuracy of drawings, models and object expression ((u_{ij}=0.50))</td>
</tr>
<tr>
<td></td>
<td>Compliance with applicable regulations on format, drawings, and experimental data ((u_{ij}=0.20))</td>
</tr>
</tbody>
</table>

Among the others, the weight of primary indexes is \( A=(0.25, 0.60, 0.25) \); and that of secondary indexes is \( A_1=(0.25, 0.25, 0.25), A_2=(0.15, 0.22, 0.15, 0.15), \) and \( A_3=(0.50, 0.20) \).

3.2 Building and implementing I&E training projects
The colleges may, according to unified arrangement and at a certain time each year, give a notice on approval and initiation of I&E training projects for civil engineering majors, and with the help of social media and new media, communicate the purpose and significance of implementing such projects for the sake of higher awareness among teachers and students (He et al., 2015). Please refer to Figure 1 for the implementation process of I&E training projects. Based on features of civil engineering major, main project types include theoretical derivation, experimental research, software development and so on, and major implementation methods include theoretical research, experimental research, software programming, numerical simulation, etc. Upon approval and initiation of a project, the instructor will guide students to prepare the implementation scheme, which is then submitted to the instructor for review, and the students may commence the next stage if the scheme is approved by the instructor (Feng, 2012). Project conclusion stage is aimed to conduct an all-round inspection on implementation progress and achievements of the I&E training projects. A defense is organized by the colleges to determine whether a project is concluded timely against each requirement for project approval and initiation. During the implementation process, civil engineering majors may, through communication with the instructor, get a better understanding on relevant employers and the working environment; and the instructor shall, based on the features of every student, provide students with targeted suggestions on career choice and in turn enhance their IE ability.

3.3 Establishing multi-dimensional practical teaching system

A multidimensional practical teaching system can be established for civil engineering majors to enhance their IE ability. It refers to the multi-faceted and multi-structured student practice and learning system that comprise off-campus production and practice base, on-campus experimental teaching center and school-enterprise innovation base (Wang et al., 2013). Establishment of such a system can help integrate on-campus practice (experiment and design), off-campus practice (internship) and university-industry collaborative projects for better organization and management (Jiang et al., 2014). Moreover, teachers shall arrange the teaching contents by centering on the I&E training projects, so as to adapt IE ability cultivation and practical teaching to latest developments in the field of civil engineering, meet employers’ demand for talents, and eliminate the gap between teaching contents and job requirements (Wu and Wang, 2016). Throughout the teaching process, teachers should encourage college students to participate in practice, so that they can give full play to their initiative during operation of the multidimensional system and make greater achievements under the guidance of teachers.

3.4 Establishing a reasonable I&E curriculum system

It is necessary to establish an I&E curriculum system for civil engineering majors that is stratified and inter-related. At present, the I&E curriculum system of civil engineering majors has such shortcomings as too many courses, unreasonable allocation of class periods, etc., with practical teaching still in the initial stage. Therefore, to improve students’ IE ability, colleges shall establish a scientific curriculum concept, and timely adjust the curriculum structure to build an I&E curriculum system that is stratified and inter-related. Attention shall be paid to principles governing organization of course contents in terms of content continuity, order and integration, to be specific, the logical order and psychological order, vertical organization and horizontal organization, as well as linear organization and spiral organization. In addition, colleges can set up a dedicated I&E education institution, and intensify efforts to curriculum reform and preparation of teaching materials (Zhang, 2017). Moreover, a curriculum research alliance can be established for the civil engineering major, which refers to a resource-sharing research community that gives priority to curriculum research and integrates faculty members good at curriculum construction. While building the organizational structure of such research alliance, importance shall be attached to students’ IE ability cultivation, and to the key needs of curriculum construction. Specific measures include teacher training, construction of model courses and building of teaching resource database (Dong et al., 2013). In short, colleges should set up an I&E curriculum system that is stratified and inter-related, and organize students to participate in I&E practice as per their practical situation, with a view to enhance students’ IE ability.

4. CONCLUSION

In a word, the paper studies the approaches for cultivating IE ability among civil engineering majors, and based on FCE method, puts forward such approaches as adopting a multi-level FCE model to evaluate graduation design quality, constructing and implementing I&E training projects, establishing a multidimensional practical teaching system and setting up a reasonable I&E curriculum system. The research results of this paper can effectively solve existing problems with IE ability cultivation among civil engineering majors, greatly enhance
IE ability of students, and achieve multi-win for students, colleges and enterprises, thus laying a solid foundation for cultivating innovative and entrepreneurial talents who can meet the demands of the 21st century.

REFERENCES


