Research on Assessment System of Student Implementing Capability under the CDIO™ INITIATIVE

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Abstract:

The purpose of undergraduate engineering education is to develop a skilled technical and extensive-based professionalism for the young engineers. The CDIO™ Syllabus and Standards meet the concept of developing the Excellent Engineers Program in China since the Ministry of Education implementing engineering educational reform in 2006. Research on assessment system of student implementing capability is to assess the effects of teaching, providing feedback to students and faculty for the purposes of continuous improvement CDIO™ engineering educational reform in collaborators, specifically the implementation of the quantification of the effect.

The topic of assessment system of student implementing capability is researched on the paper, using the Fuzzy Comprehensive Evaluation Method to establishment a simple quantitative model, then choosing three secondary indexes and fifteen tertiary indexes to take "Engineering System Design" economics-management course module as an example, which is shown that the assessment system provides a practical and effective method to assess every single student implementing capability to demonstrate their achievement by engineering faculty under The CDIO™ INITIATIVE.

Keywords：

Assessment System, Fuzzy Comprehensive Evaluation Method, Student Implementing Capability, Quantitative Model, CDIO™, Engineering Education Reform

(1) Introduce: The necessity of the assessment system of student implementing capability

The appropriateness of teaching and assessment methods depends on the nature and level of the learning outcomes. Using the same example of communication, appropriate teaching and assessment methods would be those that would allow students to practice their skills, get feedback on their performance, and in an assessment situation, demonstrate their achievement. Biggs refers to this purposeful relationship between the intended learning outcomes, teaching and learning activities,

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and assessment of student learning as constructive alignment, see Figure 1. [1]

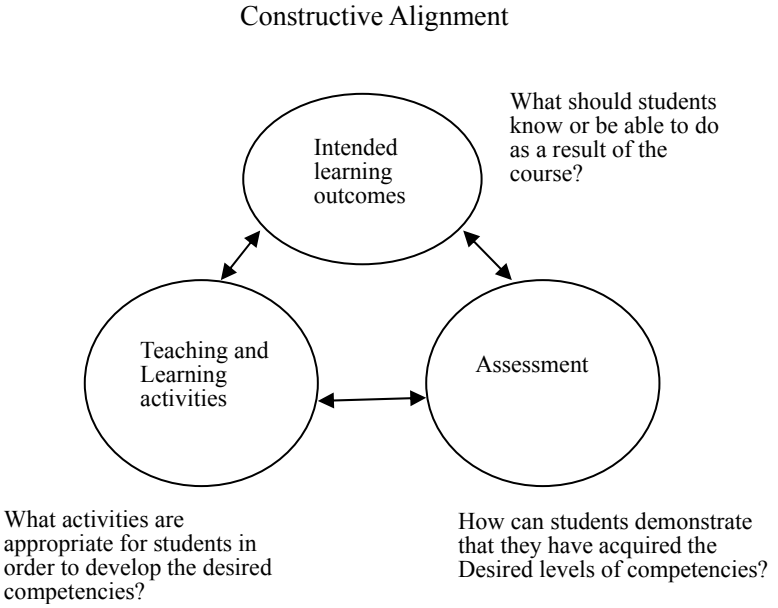

Figure 1 Alignment of intended learning outcomes with teach and assessment

(2) The comprehensive quality & philosophy training with the guidance of EIP-CDIO

The CDIO™ initiative advocated taking the following four categories of skills as training objectives: (1) Disciplinary Knowledge and Reasoning, (2) Personal and Professional Skills and Attitudes, (3) Interpersonal Skills: Teamwork and communication, (4) Conceiving, Designing, Implementing, Operating Systems in the Enterprise Societal and Environmental Context. [3, 4]

The CDIO™ Syllabus V2.0, A new statement of the underlying need for engineering education is that: Graduating engineers should be able to conceive-design-implement- operate complex value-added engineering systems in a modern team-based environment.[3,4] The four-section organization of the Syllabus reflects disciplinary knowledge, how to think, how to work with others, and how to engineer. Many universities have adopted CDIO™ initiative domestically and abroad. Now there have been 39 collaborators [5, 6] to implement the CDIO™ engineering educational reform since Shantou University was the first CDIO™ collaborator in China since 2005. Shantou University combined with China's current ethics for engineers (Ethics), integrity (Integrity) and professional qualities (Professionalism) in the contemporary requests, first proposed design-oriented EIP-CDIO engineering training model, which is committed to developing a strong foundation of engineering science, multi-disciplinary background and international perspective, excellent management and communication skills of international engineers.[7,8] For Civil Engineering Education model see details Figure 2.

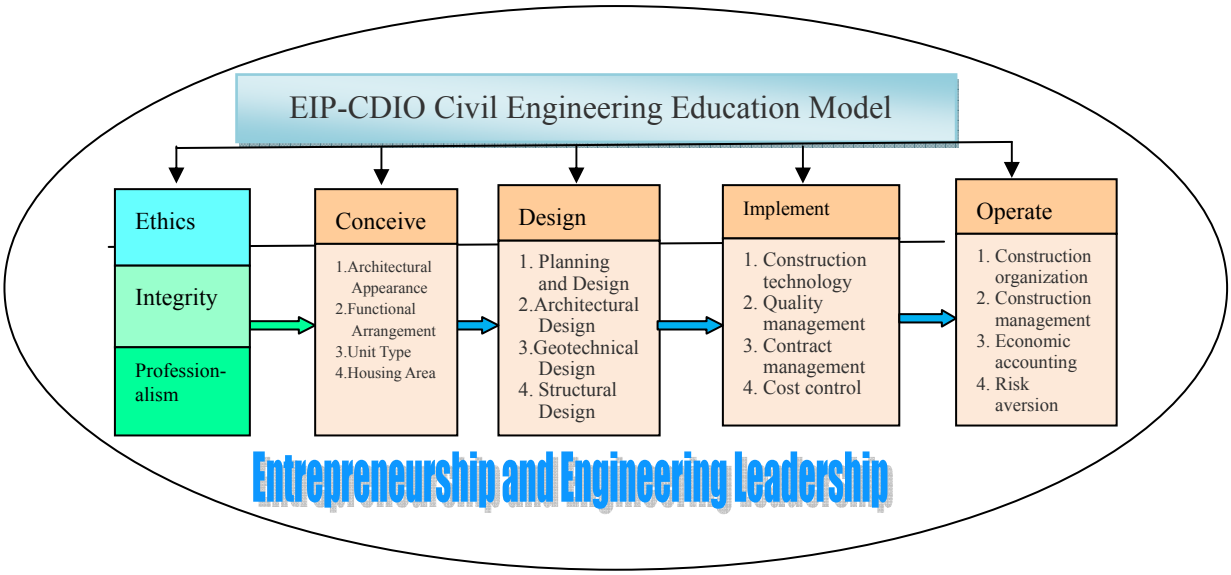

Figure 2: EIP-CDIO Civil Engineering Education Model at Shantou University

Based on the CDIO™ education curriculum, combined the Canadian reform experience, and noticed that China's ethics, integrity and professionalism (EIP) education, which need to be strengthened. The EIP-CDIO education curriculums were proposed for different undergraduate programs at Shantou University. An ability-knowledge integrated and design-oriented curriculum for Civil Engineering Program was built up based on CDIO™ Syllabus and Standards. The new curriculum started from students of 2006 and has been continually growing and improving.[8]

A survey performed by the Department of Civil Engineering showed that the EIP-CDIO ability-knowledge integrated curriculums are highly recognized by the domestic stakeholders. This curriculum takes the personal ability and interoperability as well as system operation ability as the main goals. The CDIO™ syllabus and Standards as criteria, team design projects as direction and ability-knowledge integrated course system as carrier, to greatly enhance the ability–knowledge of the students. A fishbone diagram is developed to present the features of the new curriculum with an emphasis on the design projects, like as Figure 3.

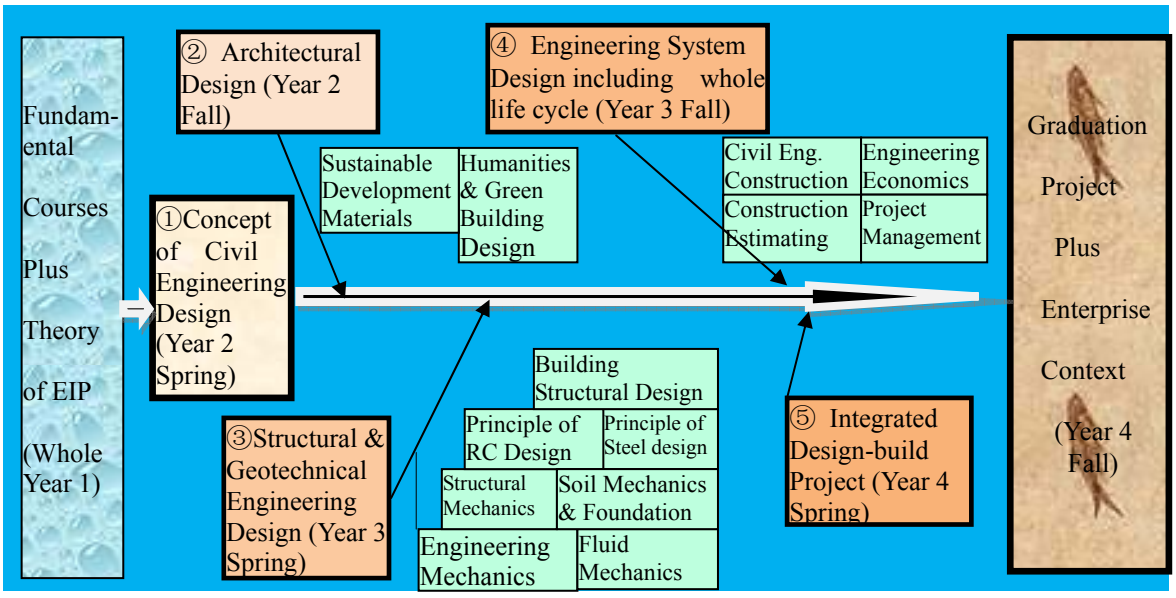

Figure 3: EIP-CDIO Curriculum Design for Civil Engineering of the practice of multi-level projects Plus Context

(3) Establishment a simple quantitative model: Taking "Engineering System Design" course module as an example

In modern society, engineers are increasingly expected to move to position of leadership, and often take on an additional role as an entrepreneur. "Engineering System Design" economics-management course module meet society requirements，its includes four courses: Civil Engineering Construction, Construction Estimating, Engineering Economics, and Project Management. After students completed three stage design：① Concept of Civil Engineering Design , ② Architectural Design and ③Structural & Geotechnical Engineering Design, then Continuing to develop Engineering System Design for students in Year 3 Fall. Engineering System Design by teamwork cooperation approach, the students use the knowledge of economics-management course module to “construction organization design” and “project evaluation” for engineering projects, which let them understand the project faces from social, environmental, and economic, technical and political restriction, learning how the relative factors, the personnel, and organization harmonious interaction to link to complete a successful project in the enterprise societal and environmental context. [9,10]

Research on assessment system of student implementing capability is to assess the effects of teaching, providing feedback to students and faculty for the purposes of continuous improvement CDIO engineering educational reform in collaborators, specifically the implementation of the quantification of the effect. The paper selects main influence factors to establishment the assessment system of index (See Chart1) to assess every single student implementing capability to demonstrate their achievement in Engineering System Design basing Figure 2 Requirements.

Chart 1： Assessment Form of student implementing capability

Student Implementing Capability (R)	Assessment Elements		Value of Assessment Target (mark √)				
			0.1 (V_{T1})	0.3 (V_{T2})	0.5 (V_{T3})	0.7 (V_{T4})	0.9 (V_{T5})
	1. Student’s quality--EIP (R_1)	Consciously law-abiding					
		Presents and develops a professional image					
		Communication skills					
		Integrity and credit					
		Pursues continuing profession development					
	2. Synthesis	Interprets drawings and scopes design requirements					

	Application of Professional Knowledge ---COID (R_2)	Application of Design and Construction					
		Structure Design of Computation					
		Construction Technology and Management Skills					
		Cost Estimation and Evaluation Ability					
	3. Practice Ability and the Attitude under Enterprise---- CDIO (R_3)	Analytical Skills and Problem-solving Ability					
		Adaptability and Flexibility					
		Continuous Learning Attitude					
		Interpersonal Relationship					
		Leadership					

(4) Application the theory of Fuzzy Comprehensive Evaluation Method

The Fuzzy Comprehensive Evaluation Method [2] is a new way to apply fuzzy systems to identification the merits of the field of things, according to the assessment criteria and given the measured values after the fuzzy transformation system of things or make a comprehensive assessment. The evaluation method steps for different application categories are different, the principle the same basic steps are summarized as follows:

Student Implementing Capability (R_T)'s factors consist of : ① Student's quality--EIP (R_1); ② Synthesis Application of Professional Knowledge (R_2); ③ Practice Ability and the Attitude under Enterprise (R_3).

Given the each factor to weighting factor $A_T = \{\omega_1, \omega_2, \omega_3, \omega_4, \omega_5\} = \{1/5, 1/5, 1/5, 1/5, 1/5\}$. The value of Assessment Target $V_T = \{V_{t1}, V_{t2}, V_{t3}, V_{t4}, V_{t5}\} = \{0.1, 0.3, 0.5, 0.7, 0.9\}$. 0.1 is "worst" expression, 0.9 is "Excellent" expression, 0.3, 0.5, 0.7 are between "worst "and "Excellent" expression. Which are present that each factor's relation between R_1, R_2 or R_3. The Teacher who teaches the course provides Value of Assessment Target basing on the Assessment Elements in Chart 1 to assessment the level of student implementing under the COID for single student.

4.1 Identify Factor of Student's quality--EIP (R_1)

The teacher provides the Value of Assessment Target to assesse one student's quality--EIP (R_1) as basing on the below chart 2:

Chart 2: Assessment Form of Student's Quality--EIP (R_1)

Assessment Elements		Value of Assessment Target (mark √)				
		0.1 (V_{T1})	0.3 (V_{T2})	0.5 (V_{T3})	0.7 (V_{T4})	0.9 (V_{T5})
1. Student's quality--EIP (R_1)	Consciously law-abiding (A_{1i})					
	Presents and develops a professional image (A_{2i})					
	Communication skills (A_{3i})					
	Integrity and credit (A_{4i})					
	Pursues continuing profession development (A_{5i})					

For obtaining the Fuzzy relation matrix from R_1 to A_{ii}, we combine five factors to one matrix:

$$R_1 = \begin{bmatrix} A_{11} \\ A_{22} \\ A_{33} \\ A_{44} \\ A_{55} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix} \quad (1\text{-}1)$$

Then continue to Fuzzy Comprehensive Evaluation:

$$B_1 = A_T \,.\, R_1 = \{\omega_1, \omega_2, \omega_3, \omega_4, \omega_5\} \,.\, \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix} = [\, b_1, b_2, b_3, b_4, b_5] \quad (1\text{-}2)$$

If each component in B_1 is not equaled to 1, so it needs to be normalized:

$$B_1' = \left[b_1', \quad b_2', \quad b_3', \quad b_4', \quad b_5' \right] \quad (1\text{-}3)$$

So obtaining the value of Student's quality—EIP:

$$R_1' = B_1' \bullet V_1^T = \left[b_1', \quad b_2', \quad b_3', \quad b_4', \quad b_5' \right] \bullet \begin{bmatrix} 0.1 \\ 0.3 \\ 0.5 \\ 0.7 \\ 0.9 \end{bmatrix} = 0.1b_1' + 0.3b_2' + 0.5b_3' + 0.7b_4' + 0.9b_5' \tag{1-4}$$

4.2 Using the same theory and method to identify factor of the synthesis application of professional knowledge (R_2') and practice ability and the attitude under enterprise (R_3')

4.3 Identify whole factor of Student Implementing Capability (R)

Through using the Fuzzy Comprehensive Evaluation Method to calculate the factor R_1', R_2' and R_3', so the outcome of student's implementing capability (R) is

$$R = 1 - (1 - R_1')(1 - R_2')(1 - R_3') \tag{1-5}$$

(5) Conclusion:

There are many factors to influence student's implementing capability for undergraduate curriculums. On this paper, the output index only includes three secondary indexes and fifteen tertiary indexes to assess student's implementing capability by Fuzzy Comprehensive Evaluation Method. So the research is shown:

（1）Student implementing capability to be distinguished: worst, poor, ordinary, good, excellent;

（2）Quantitative model for every single student;

（3）Effective assessment method.

And the research only selects limited fifteen tertiary indexes. For obtaining more accuracy result, we can select deferent factors to assess student's implementing capability by applying Fuzzy Comprehensive Evaluation Method.

(6) References:

[1] Biggs, J., "Teaching for Quality Learning At University", 2nd ed., The Society for Research into Higher Education and Open University Press, Berkshire: England, 2003

[2] Guoli zhang, Hui Zhang, Qian Kong, "Principles and Applications of fuzzy mathematics", Chemical industry press, Beijing, 2011.9

[3] Edward F. Crawley, Johan Malmqvist, William A. Lucas, Doris R. Brodeur, "The CDIO Syllabus V2.0 An Undated Statement of Goals for Engineering Education", Proceeding of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June, 20-23, 2011

[4] Http://www.cdio.org

[5] 2011 National Conference and CDIO engineering education reform, the Ministry of Education Senior CDIO Seminar, Nanjing Institute of Technology, Nanjing, China, Dec. 16~18, 2011

[6] Http://www.chinacdio.cn

[7] Lu Xiaohua, Xiong Guangjing, Chen Zhulin, "Design- DirectedEngineering Education Reform Initiative", Journal of Research in higher education of engineering, 2010(6): 83~87

[8] Http://www.eng.stu.edu.cn

[9] Yang Yunping, Xiong Guangjing, Wang Yingzi, "Training Student's Comprehensive Abilities in Engineering System Design Course", Journal Architectural Education in Instructions Higher Learning, Vol. 20, 2011(5): 35~ 40

[10] Wang Yingzi, Xiong Guangjing, Kang Quanli, "Case Study on the "Ability –Quality-Knowledge" Structure in Housing Architecture Curriculum Syllabus and Teaching Practice", Journal of Research in higher education of engineering, 2010(01) : 155~158.